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SOME PHASES OF STEAM-RAILROAD ELECTRIFICATION IN THE UNITED STATES.

By Edward N. Lake.

There are many indications that the revival of prosperity, now clearly in progress, will have as one of its distinguishing features a marked activity in heavy railway electrification. While special instances may seem to depend—and may depend—on special conditions, local and incidental in character, yet the movement at large is governed by great economic principles and laws. These can be seen only by getting a general viewpoint and a large survey of data and phenomena. To this very interesting and profitable study Mr. Lake's article is addressed.—THE EDITORS.

"E lec tri" ci ty, n. a property in bodies, whereby, when rubbed, they draw substances and emit fire."

THIS quaint definition is taken from an advanced school book of our grandfathers, "The New-York Expositor or Fifth Book," to which there is appended "A Vocabulary of Scientific Terms" and upon the title page of which it is stated that it was published in "New-York" in the year 1818, or a little more than ninety years ago.

It, however, represents without doubt the extent of the popular knowledge of electricity even as late as fifty years ago, notwithstanding the fact that the telegraph had then been in use more than two decades and the first Atlantic cable had then been laid about a year.

It is only about twenty-five years ago that incandescent electric lamps were an especially advertised feature of our expositions, and the electric arc lamp was gorgeously pictured upon the bill boards as a "marvel" of the traveling circus.

Although it has been about sixty years since the early work of Davenport, Farmer, and Hall upon the problem of applying electricity to the propulsion of vehicles, it has only been a little over twenty years since the opening of the Richmond trolley lines.

It is now hardly twenty-five years since the experimental work of Daft and Sprague on the third-rail operation of the New York elevated roads, but only seven years since the electrification of the Manhattan Elevated lines, although the Chicago elevated roads had been operating electrically for five or six years previously.

The "Judge," a quaint little electric locomotive, hauled loads of wondering and delighted visitors at the Louisville exposition a quarter of a century ago. At the Baltimore tunnel, fourteen years ago, the electric locomotive demonstrated its ability to handle heavy steam-railway train service, but it is only two years now since commencement of the electrification of the New York Central terminals.

Such have always been the slow processes in the preliminary stages when a change of world-wide effect is to be made. The scientific investigator makes the discovery of the principle and evolves an abstruse theorem or two and gives them to the world. A few centuries or a few generations afterwards, an inventor applies these principles to a practical appliance for accomplishing some part of the world's work. Then after a while, in its deliberate way, the industrial world takes it up, turns it over, says, "this I cannot use yet, this I can use with this modification, this I will make my own and use it as it is;" and a new world period has begun.

Thus it was that the power of steam and the principles of its operation were known by Hero more than twenty centuries ago, but it took Watt, less than a century and a half ago, to devise a commercially practical steam engine; it has, however, only been in comparatively recent years that the engine of this type has reached its highest development, and only in the last decade that Curtis, Parsons, and Rateau, going back two-thousand years and taking one of Hero's devices, have developed a commercial steam turbine which in some large fields is crowding out entirely the reciprocating engine of the type which Watt developed.

The commercial world is very deliberate about taking up and adopting new and radical departures from its accepted methods of doing things. To illustrate this "inertia" of the world of industry here are two specific instances.

A certain purchaser's engineer specified certain new modifications in an old and staple metal product. This new requirement was apparently overlooked by the manufacturer's sales department, and was only discovered when the order was entered up at the factory office, preparatory to sending it through the several departments of the mills. Then ensued weeks of correspondence in which letters multiplied and grew fat traveling from purchaser's engineer

to manufacturer's general offices, and from manufacturer's district office to manufacturer's factory office and back again two or three times over; all of the manufacturer's large organizations apparently agreeing that the new requirements of purchaser's engineer were impracticable and impossible.

Now it so happened that these requirements were of considerable importance to the purchaser, so purchaser's engineer traveled many miles to manufacturer's extensive works, where, after being passed along from office boy to department superintendent, to general superintendent and back to office boy, and then down through an untraced line of minor employees, he finally reached the operator of the machine which had to do with the particular new requirements. There after five-minutes talk with the man who actually did the work, it was found that two or three dollars worth of changes on the machine would take care of the new modifications without increase in the cost of the product.

Another case is that of a young engineer in a large manufacturing plant who devised and proposed an improvement in the design and manufacture of a certain old standard part of their apparatus. Machine operator, machinists, department foreman, general foreman, and even the shop superintendent, declared the change to be impracticable and found numerous reasons why it could not be done in any other way than "the way we have always done it." The young engineer was firmly convinced that he was on the right track, and so in due time, when the opportunity presented itself, it was placed before the general manager with the result that a special order marked in large red letters "rush" went through the factory, and the same men who had found so many objections readily found means of overcoming these same objections and added certain important modifications of their own, so that the final improvement was much better than the one first proposed.

In one case it required the practical knowledge of a machine operator of the specific functions of his machine, and in the other case the peremptory order of a general manager, to overcome the natural reluctance to taking up anything new and to secure the introduction of an improvement.

After the industrial inertia has once been overcome, however, the rapidity with which a really advantageous appliance or system is developed and put into general use, is truly marvelous. This has been especially true of the growth of electrification into the street-railway systems of the United States and the consequent growth of street railways under the influence of electrification. As will be seen

from the following figures, comparing 1890—only two years after the opening of the pioneer commercial trolley lines in Richmond—with the years 1902 and 1907, the changes in a few years were really wonderful. The figures for 1890 and 1902 are from published bulletins of the Census Bureau, while those for 1907 are from a bulletin soon to be issued:

Miles of Single Track—	1890.	1902.	1907.
Operated by animals	5,662	259	136
Operated by cable	488	241	62
Operated by steam	711	170	105
Operated by gasolene	...	...	41
	6,861	670	344
Operated by electricity	1,262	21,907	34,060
Total	8,123	22,577	34,404
Per cent of total miles which were operated by electricity	15.5	97.0	99.0
Increase in miles operated by electricity over 1890, per cent	...	1636.0	2546.8
Average annual increase corresponding to above, per cent	...	136.3	149.8

It is interesting to note from these figures that the mileage of electrically operated street railways increased at the marvelous rate of 149.8 per cent, or in even numbers 150 per cent per year, for the seventeen years to 1907.

Out of the electrification of street lines, first has come a shifting of residence population into suburbs and then the extension of the suburban tip-ends of one city system to connect with the extended suburban tip-ends of another city system, and so the electric interurban networks have formed about population centers all over the country. In 1890 the interurban railway was not of sufficient importance to be considered separately by the Census Bureau. In 1902 there were 8,729 miles valued at $459,000,000. This truly remarkable growth of the urban and interurban electric railways has undoubtedly been a direct result of the peculiar adaptability of the electric motor to the operation of cars for the frequent-service, short-haul conditions in and about population centers.

The successive stages of railroad electrification have been developed and extended by zones about the centers of population: First, the urban street railway operating immediately in the populous centers, then the suburban electric railway in the residence zone, then the interurban electric railway reaching into the country district, and now we have a few examples of the electrified steam-railway terminal serving a still wider zone of suburbs, country, and adjacent towns. When our larger population centers are thus served by the

electrified steam-road terminals it is logically certain that, just as in the case of the interurban electric lines, the tip-ends of one electrified steam terminal system will be connected to the tip-ends of another electrified steam terminal system, and so will come the enlarged electrified network which will ultimately become one country-wide system of electrified steam railroads.

Already, according to published reports, the New York, New Haven and Hartford are preparing to electrify their Boston terminals and connect this new electrified terminal with the present electrified zone extending out from New York.

If we may draw any conclusions as to the rapidity of the future growth of steam-railway electrification from the history of the phenomenal growth of the electrified urban railway, and of the electric interurban railway—if the New York Central and the New York, New Haven and Hartford electrifications are to the era of electrified steam railways what the Richmond trolley was to the era of electricity in street and interurban railways—then we may expect a very rapid and wide-spread application of electricity to steam-railway properties in the next decade.

New York is the great eastern center of population about which the ganglion of electrified steam railways is forming with their tipends extending out toward other population centers. What will be the western center whose electrified network will reach out its tip-ends to connect ultimately with the eastern center and form one or more electrified trunk lines from east to west? Undoubtedly Chicago, that half-century-old marvel of western cities which is now second as a population center and whose peoples now number roughly 66 2-3 times what they did fifty years ago, will be this western center.

A comparative study of the steam-railway valuations and mileage, and of the population and land area contiguous to these two great cities, reveals instructive and significant figures from which we may form some estimate of their possible future importance as railroad centers.

A circle having a radius of four-hundred statute miles, drawn about New York as the center, includes all or the larger part of thirteen States. A like circle with Chicago as its center includes all or a large part of nine States. These twenty-two States which are shaded on the map (on page 491) to show the geographical relation of the two groups, constitute about half of the present number of States, but only about one-fourth of the land area of the States and territories, exclusive of Alaska and the insular possessions.

TABLE I.—COMMERCIAL VALUES OF RAILWAY OPERATING PROPERTY IN STATES CONTIGUOUS TO NEW YORK AND CHICAGO AS OF JUNE 30TH, 1904.

GROUP I.—States entirely or largely within a circle about New York city as the center, having a radius of 400 miles.

GROUP II.—States entirely or largely within a circle about Chicago as the center, having a radius of 400 miles.

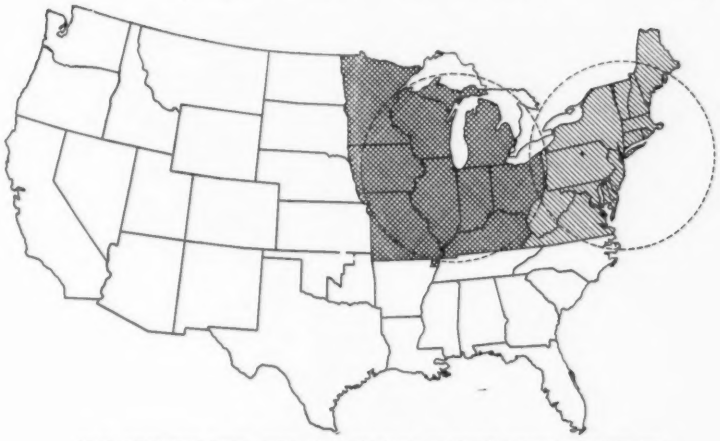
Figures from the individual states are from Census Bulletin No. 21.

GROUP I.	Commercial Value of Operating Property.	Per cent of Total in the U. S.	Rank of State.
Pennsylvania	$1,420,608,000	12.63	1
New York	898,222,000	7.99	2
New Jersey	333,568,000	2.97	10
Massachusetts	250,052,000	2.22	15
Virginia	211,315,000	1.88	17
West Virginia	201,799,000	1.80	18
Maryland	132,342,000	1.18	25
Connecticut	105,369,000	.94	32
Maine	80,146,000	.71	38
New Hampshire	79,786,000	.71	39
Vermont	37,311,000	.33	47
Rhode Island	25,719,000	.23	48
Delaware	17,285,000	.15	49
Total 13 States	$3,793,522,000	33.74	.

GROUP II.	Commercial Value of Operating Property.	Per cent of Total in the U. S.	Rank of State.
Illinois	$805,057,000	7.16	3
Ohio	689,797,000	6.13	4
Minnesota	466,734,000	4.15	5
Indiana	375,541,000	3.34	6
Iowa	344,847,000	3.07	9
Missouri	309,768,000	2.76	11
Wisconsin	284,510,000	2.53	12
Michigan	277,597,000	2.47	13
Kentucky	155,772,000	1.39	23
Total 9 States	$3,709,623,000	33.00	
Total 22 States	$7,503,145,000	66.74	
Total United States	$11,244,852,000	100.00	

While the land area of these two groups is small it is a part of the country which contains some of its most highly developed sections, and as will be seen from the comparisons which follow, these two cities are the twin centers around which are grouped the largest part of the country's steam-railway property and the largest part of our population.

Tables I to IV inclusive give respectively the commercial values of railroad property, the mileage of steam railways, the population, and the land areas of the two groups by States. There are also given the totals for each group, the totals of the two groups, and the total for the United States, together with the corresponding percentages to facilitate comparison.



MAP SHOWING NEW YORK AND CHICAGO AS POPULATION CENTERS ON 400-MILE RADIUS.

Table V is a comparison of the group totals in these four tables, and also contains some very interesting percentages, from which it will be noted that five of the eight group percentages are 33, two are practically one-half of 33, and the other is approximatelv one-fourth of 33. Using the nearest common fraction with a plus or minus sign to indicate whether the approximation is over or under the actual figures, the following gives the approximate parts of the totals for the United States:

	New York Group.	Chicago Group.	Both Groups.
Commercial values, 1904	1/3 +	1/3 —	2/3 +
Mileage, 1904	1/6 +	1/3 +	1/2 +
Population, 1900	1/3 —	1/3 —	2/3 —
Land areas, 1900	1/12—	1/6 —	1/4 —

It will thus be seen that nearly equal numbers of population and equal values of steam-railway property are tributary to Chicago and to New York, but the railway mileage and the land area in the western group are each almost exactly double the mileage and area in the eastern group. The conclusion from this must be that with future improvements of railway properties and future development of the land areas, Chicago may be expected to increase in importance as a railroad center and a population center at a more rapid rate than will the eastern metropolis, and as electrification gradually becomes general and is applied to trunk-line steam systems and large steam-road net works, Chicago will naturally and certainly become the great western terminal of these electrified trunk lines and the great western center of these electrified networks.

TABLE II.—MILEAGE OF STEAM RAILWAYS IN STATES CONTIGUOUS TO NEW YORK AND CHICAGO AS OF JUNE 30TH, 1904.

GROUP I.—States entirely or largely within a circle about New York city as the center, having a radius of 400 miles.

GROUP II.—States entirely or largely within a circle about Chicago as the center, having a radius of 400 miles.

Mileage for the individual States is from Census Bulletin No. 21.

GROUP I.	Miles of Single Track.	Per cent of Total in the U. S.	Rank of State.
Pennsylvania	11,023	5.15	3
New York	8,297	3.88	8
Virginia	3,932	1.84	19
West Virginia	2,837	1.33	30
New Jersey	2,278	1.06	34
Massachusetts	2,119	.99	35
Maine	2,022	.95	36
Maryland	1,421	.66	40
New Hampshire	1,276	.60	42
Vermont	1,063	.50	44
Connecticut	1,018	.48	45
Delaware	336	.16	47
Rhode Island	212	.01	48
Total 13 States	37,834	17.61	

GROUP II.	Miles of Single Track.	Per cent of Total in the U. S.	Rank of State.
Illinois	11,623	5.43	2
Iowa	9,859	4.61	4
Ohio	9,197	4.30	5
Michigan	8,660	4.05	7
Minnesota	7,811	3.65	9
Missouri	7,711	3.60	10
Wisconsin	7,049	3.29	11
Indiana	6,918	3.23	12
Kentucky	3,253	1.52	26
Total 9 States	72,081	33.68	
Total of above 22 States	109,915	51.39	
Total in United States	213,932	100.00	

In the electrification of elevated railways Chicago antedated New York by some six years, but has apparently been content to wait for the valuable results and experience to be gained from the electrical operation of the New York terminals before venturing into the field of steam-road electrification. It is now apparent, however, from the activity which is being manifested by the Illinois Central Railroad, that New York will not much longer enjoy the distinction of having the only large electrification projects in the United States.

To the popular ear the word electrification has the sound of something deeply mysterious and greatly complicated. To the steam-railroad man who has not had an opportunity of making a study of the subject it sounds complicated and expensive. Ex-

TABLE III.—POPULATION BY CENSUS OF 1900 IN STATES CONTIGUOUS TO NEW YORK AND CHICAGO.

GROUP I.—States entirely or largely within a circle about New York city as the center, having a radius of 400 miles.

GROUP II.—States entirely or largely within a circle about Chicago as the center, having a radius of 400 miles.

GROUP I.	Population in 1900.	Per cent of Total in the U. S.	Rank of State.
New York	7,268,894	9.53	1
Pennsylvania	6,302,115	8.26	2
Massachusetts	2,805,346	3.68	7
New Jersey	1,883,669	2.47	16
Virginia	1,854,184	2.43	17
Maryland	1,188,044	1.56	26
West Virginia	958,800	1.26	28
Connecticut	908,420	1.19	29
Maine	694,466	.91	30
Rhode Island	428,556	.56	34
New Hampshire	411,588	.54	36
Vermont	343,641	.45	38
Delaware	184,735	.24	42
Total 13 States	25,232,458	33.08	

GROUP II.	Population in 1900.	Per cent of Total in the U. S.	Rank of State.
Illinois	4,821,550	6.32	3
Ohio	4,157,545	5.45	4
Missouri	3,106,665	4.07	5
Indiana	2,516,462	3.30	8
Michigan	2,420,982	3.17	9
Iowa	2,231,853	2.92	10
Kentucky	2,147,174	2.81	12
Wisconsin	2,069,042	2.71	14
Minnesota	1,751,394	2.30	19
Total 9 States	25,222,667	33.05	
Total 22 States	50,455,125	66.13	
Total United States	76,303,387	100.00	

pensive, because he has visions of a large portion of the railway property and equipment going directly to the "scrap heap" with the advent of electrification. In reality, electrification is simple in its elements and affects only a very small percentage of the value of the railway property. Furthermore, the part which is displaced will not go any more rapidly or any more directly to the scrap heap than under non-electrified operation.

Reduced to its simplest terms, electrification consists in substituting for the steam locomotives three electrical elements, viz: A generating system, a distributing system and a motive system. Basing an estimate upon the total number of steam locomotives in the United States, reported as of June 30, 1908, which was in round

TABLE IV.—LAND AREA OF STATES CONTIGUOUS TO NEW YORK AND CHICAGO.

GROUP I.—States entirely or largely within a circle about New York city as the center, having a radius of 400 miles.

GROUP II.—States entirely or largely within a circle about Chicago as the center, having a radius of 400 miles.

Total land area is exclusive of Alaska, Hawaii and Philippines.

GROUP I.	Square Miles of Land Area.	Per cent of Total in the U. S.	Rank of State.
New York	47,620	1.60	28
Pennsylvania	44,985	1.51	31
Virginia	40,125	1.35	34
Maine	29,895	1.00	40
West Virginia	24,645	.83	41
Maryland	9,860	.33	42
Vermont	9,135	.31	43
New Hampshire	9,005	.30	44
Massachusetts	8,040	.27	45
New Jersey	7,525	.25	46
Connecticut	4,845	.16	47
Delaware	1,960	.07	48
Rhode Island	1,053	.04	49
Total 13 States	238,693	8.02	

GROUP II.	Square Miles of Land Area.	Per cent of Total in the U. S.	Rank of State.
Minnesota	79,205	2.67	13
Missouri	68,735	2.31	17
Michigan	57,430	1.93	20
Illinois	56,000	1.89	21
Iowa	55,475	1.87	22
Wisconsin	54,450	1.83	23
Ohio	40,760	1.37	33
Kentucky	40,000	1.35	35
Indiana	35,910	1.21	37
Total 9 States	487,965	16.43	
Total 22 States	726,658	24.45	
Total United States	2,970,038	100.00	

numbers 55,000, and allowing an average estimated value of $11,500 each, it will be seen that this represents a value of $632,500,000. But the total estimated value of all steam-road property on the same date was $13,000,000,000, so that the locomotive investment was only 4.86 per cent, or say 5 per cent of the total value of railway property. Then it must be borne in mind that the average life of a steam locomotive is only about twenty years, and that an average number of 2,161 locomotives per year has been purchased during the four years ending June 30, 1908. So it is apparent that each of the locomotives displaced by electrification will have abundant opportunity to serve out its allotted life on some branch line or remote service, and that no loss by "scrapping" of serviceable equipment need be taken into account in an electrification project.

A steam locomotive is a highly perfected portable power plant, consisting of fuel storage, water storage, boiler equipment, steam engines, and a cab for the operators and control apparatus, all mounted on wheels. Coal and water must be provided at convenient points along the railway lines so that the locomotive storage of these necessities may be replenished when required.

TABLE V.—A COMPARATIVE SUMMARY OF VALUES OF RAILWAY OPERATING PROPERTY, MILEAGE OF STEAM RAILWAYS, POPULATION AND LAND AREAS OF STATES CONTIGUOUS TO NEW YORK AND CHICAGO.

GROUP I.—Consists of the thirteen States which are entirely or largely within a circle having a radius of 400 miles about New York as the center.

GROUP II.—Consists of the nine States which are entirely or largely within a circle having a radius of 400 miles about Chicago as the center.

	GROUP I. NEW YORK AS CENTER.	GROUP II. CHICAGO AS CENTER.	TOTAL GROUPS I. AND II.	TOTAL UNITED STATES.
Values in 1904...	$3,793,522,000	$3,709,623,000	$7,503,145,000	$11,244,852,000
Mileage in 1904...	37,834	72,081	109,915	213,932
Population in 1900	25,232,458	25,222,667	50,455,125	76,303,387
Land area in sq. miles.....	238,693	487,965	726,658	2,970,038
Percentages:				
Values, 1904.....	33.74	33.00	66.74	100
Mileage, 1904.....	17.61	33.68	51.39	100
Population, 1900...	33.08	33.05	66.13	100
Land area.....	8.02	16.43	24.45	100

It is almost invariably true that large quantities of a commodity can be procured more economically than small quantities can. Energy for operating trains may be considered as a commodity. The average nominal horse power of all the steam locomotives now in use in the United States would probably be not much over 500 horse power each, while each of the several stationary units of a modern electrical power station would have a capacity of 10,000 to 20,000 horse power. The power station is located so that fuel and water supply can be supplied economically, is equipped with highly perfected apparatus for handling fuel, has a highly developed organization to operate it; so that energy for operating trains can be produced more economically in one electrical power plant of say 20,000 horse-power capacity than it can in forty separate and portable power plants of 500 horse power each.

Since electrical energy can be efficiently transmitted over distances of 100 to 200 miles, some further economies can be taken advantage of by locating the power plants at the coal mines, and instead of hauling the coal away in long and numerous trains of gondolas, the energy of the coal will be transmitted through the small wires of the electrical circuits to the points where it is required. Full advantage can also be taken of water powers, now

undeveloped because of lack of market for the energy. This power in the form of electrical energy will be far more economical in many locations than the same amount of power from the use of coal.

In the two New York electrification projects now in operation two different systems have been installed and may be said to be in process of trying out. The New York Central uses direct-current electricity delivered to the motors by means of a working conductor in the form of a third rail. The New York, New Haven and Hartford uses alternating current delivered to the motors by means of a working conductor in the form of an overhead trolley wire. In both systems, if electrical energy is transmitted for long distances to the point where it is delivered to the working conductors, the transmission is accomplished by means of high-potential alternating current.

In the middle west, in the tunnels under the St. Clair river, these two systems will also be used and tried out side by side. In the Grand Trunk tunnel between Port Huron and Sarnia there has recently been placed in operation an electrified section using the alternating-current overhead-trolley system. At the Michigan Central tunnel, now being constructed under the same river at Detroit, the direct-current third-rail system will be used.

This trying out of the two systems side by side in similar kinds of service is very fortunate with reference to the ultimate development and success of steam-road electrification. Each system has been developed and placed on the market by a different manufacturing corporation of large resources and unquestioned responsibility. Each of these companies has had long experience in the design and manufacture of electrical-power apparatus, and each has brought forward a complete and successful system of electrification, first for street and interurban railways and then for steam-road operation. This competition insures in the trying-out periods of early operation and, in fact, at all subsequent times, the most careful watchfulness on the part of the highly trained experts of each company to discover any defects in the apparatus or any improvements that can be devised to take care of the service better and more economically. It was a foregone conclusion, considering the ability and prestige of the engineers who designed the systems and directed the installation, the experience and responsibility of the companies who manufactured the apparatus, and the care with which each detail was worked out and tested out, that no defects of any serious importance would develop. Some minor and petty difficul-

ties have been encountered, but these are inevitable in the development and perfection of any new device or system.

It is interesting to note in this connection that representatives of each railroad are enthusiastic as to the applications and results of electrification, and that each is certain and can give many pages of reasons why the system installed on his own particular railroad is better than that installed upon the rival road.

Mr. W. J. Wilgus, chief engineer during electrification and later vice-president of the New York Central railroad, who was also chairman of the Electric Traction Commission, presented before the American Society of Civil Engineers some months ago a very complete report of the results of the operation of that railway's electrified lines. One is peculiarly impressed, in reading this paper, with the idea that there are apparently no objections to electrical operation by means of the direct-current third-rail system, but there are pages of advantages given and they are stated in percentages, too. For instance, Mr. Wilgus states that electrification has increased the capacity of the New York passenger terminal 33 1-3 per cent, has decreased locomotive repairs and fixed charges 19 per cent, and effected net earnings in various classes of service of 12 per cent to 27 per cent, besides abolishing the nuisances of smoke and foul air and corrosive fumes incident to the use of the steam locomotive.

Mr. W. S. Murray, electrical engineer of the New York, New Haven and Hartford railway, has recently presented a paper before the American Institute of Electrical Engineers, in which he expresses himself very positively as to the superior advantages of the alternating-current overhead-trolley system in operation on the electrified lines of that road. One of his concluding paragraphs is so like an epigram that it is quoted. "History sustains the undeniable truth that alternating current is the preferred agent for the transfer of electricity where either distance or capacity is involved. A railroad involves both."

From the experience of these two railroads and the reports of these two eminent engineers, it is apparent that either system of electrification, if selected after due investigation and consideration on the part of the management and the engineers, will be successful in operation and will ever afterwards be heralded by those responsible for its selection as the only really satisfactory, economical, and reliable system of electrified railroad operation.

THE EQUIPMENT OF THE UNITED STATES EXPLOSIVES-TESTING STATION.

By Clarence Hall.

This official report of the preliminary result of tests is prepared by the expert in charge of the Explosives Section of the United States Geological Survey for presentation before the Seventh International Congress of Applied Chemistry, London, June, 1909. The station is under the general direction of Dr. Joseph A. Holmes, expert in charge of the Technologic Branch of the Survey, and this complete text and illustration of Mr. Hall's paper is supplied especially to The Engineering Magazine by the courtesy of the Technologic Branch, and published by permission of the Director.—The Editors.

THE tests of the Explosives Section of the Mine Accidents Division, United States Geological Survey, Department of the Interior, are both chemical and physical. The chemical tests include the analyses of the explosives, the chemical examination of the products of combustion, stability and exudation tests, and other tests necessary to determine the effects of storage and the keeping qualities of explosives. The physical tests are conducted in:—

1. Gas and dust gallery No. 1,
2. Ballistic pendulum, and on the following pieces of apparatus installed in Building No. 17 for the determination of various physical factors:
3. Trauzl lead blocks,
4. Small lead blocks,
5. Calorimeter,
6. Rate of detonation of high explosives,
7. Flame-test apparatus,
8. Impact machine,
9. The determination of the maximum distance of propagation of the explosion wave,
10. Rate of burning of slow explosives,
11. Bichel pressure gauges, and
12. Black-powder separator.

1.—Gas and Dust Gallery No. 1.

Gas and Dust Gallery No. 1 is cylindrical in form, 100 feet long, and has a minimum internal diameter of 6 feet 4 inches. In consists of fifteen similar sections each 6 feet 8 inches long, and is built up in in-and-out courses. The first three sections nearest the concrete

head are made of ½-inch boiler-plate steel; the remaining twelve sections of ⅜-inch boiler-plate steel of at least 55,000-pounds tensile strength per square inch. Each section has one release pressure door on top equipped with a rubber bumper to prevent its destruction when opening quickly. In use, this door may be either closed and unfastened, closed and fastened by means of stud bolts, or left open. Each section is also equipped with a ¾-inch plate-glass window 6 by 6 inches. All windows and doors are centrally placed.

The sections are held together by a lap joint. At each lap joint there is on the interior of the gallery a 2½-inch circular angle iron upon the face of which a paper diaphragm may be placed and held in position by semi-circular washers, studs, and wedges. These paper diaphragms are, of course, used to assist in confining the gas and air mixture.

The natural gas used is from the mains in the city of Pittsburg, a typical analysis of which is as follows:

	per cent.
Carbon dioxide	0.0
Oxygen	0.2
Heavy hydrocarbons	0.0
Carbon monoxide	0.0
Methane	85.3
Ethane	11.8
Nitrogen	2.7
	100.0

The volume of gas entering is measured by a very accurate test meter reading to 1-20 of a cubic foot. The gas enters the required division (three sections) or divisions of the gallery near the bottom from a 2-inch perforated gas pipe 14 feet long. The perforations are so arranged that an equal flow of gas is maintained from each unit length of this pipe.

Each division is further equipped with an exterior circulating system, providing an efficient method of mixing the gas with the air. For the first division this circulation system is stationary, a portion of the piping being equipped with heating coils for maintaining a constant temperature of the mixture. All other divisions have a common circulating system mounted on a truck which may be used on any one of these divisions. Valves are provided for isolating the fan so that a possible explosion will not injure it.

The center section of each division is provided with an indicator cock, which is used for two purposes: (1), for indicators to record pressure above and below atmosphere; (2), for providing an opening whence samples of the mixture may be procured. All divisions of

the gallery are equipped with shelves laterally arranged so that coal dust may be placed thereon.

The cannon in which the explosive is fired is imbedded in the concrete head, the axial line of the bore hole being coincident with the axial line of the gallery. The cannon consists of two parts, a jacket and a liner. The jacket is 36 inches long, 24 inches external diameter, and 9½ and 7½ inches internal diameter, and is made of best cast steel, cast iron or vanadium steel. The liner is 36½ inches long, with a 1-inch shoulder 7¾ inches from the back, changing the diameter from 9½ inches to 7½ inches, having a smooth bore 2¼ inches in diameter and 21½ inches deep. The face of the cannon is even with the face of the concrete head.

The charge is fired electrically from the Observation Room, and (that the risk of charging the cannon may be minimized) the charger carries in his pocket the plug of a stage switch (this being the only one of its kind on the grounds), so that it is impossible to complete the circuit until the charger has left the gallery.

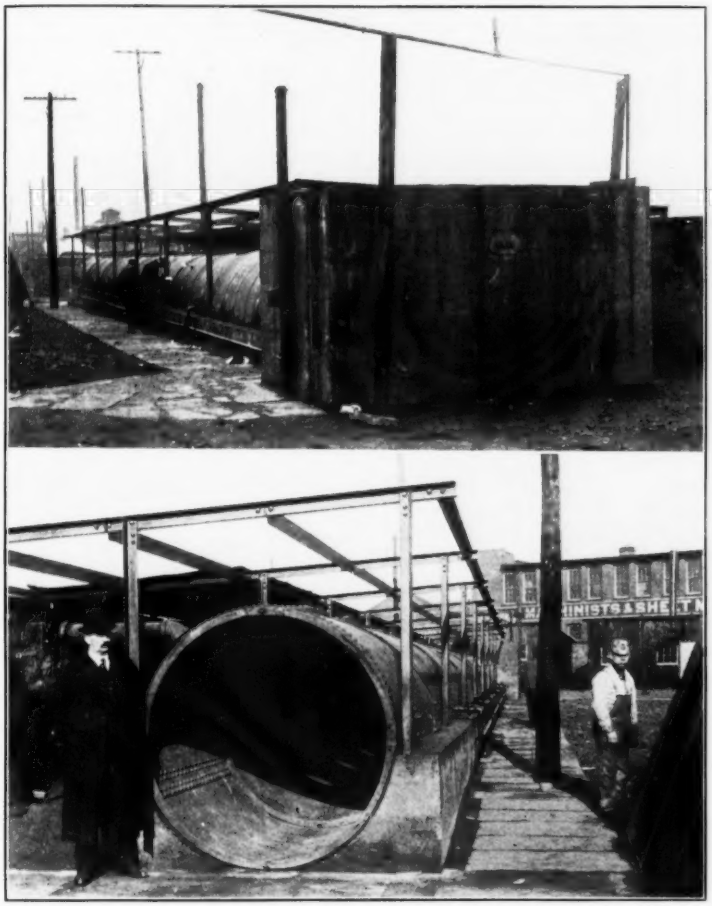
The portion of the first division of the gallery which is not in concrete has a 3-inch covering, consisting of blocks of magnesium, asbestos fibre, asbestos cement, a layer of 8-ounce duck, and then a dry-proof roofing, the whole being covered with a thick coat of graphite paint; all this, of course, to assist in maintaining a constant temperature. The entire gallery rests on a concrete foundation 10 feet wide, with a maximum height of 4 feet 6 inches, and a minimum height of 2 feet.

The concrete head in which the cannon is placed completely closes that end of the gallery. A narrow drain extending under the gallery its entire length and a tapped hole at the bottom of each section provides an efficient method for drainage.

The buildings near the gallery are protected by two barricades near the open end of the gallery, each 10 feet high and 30 feet long. A back-stop 6 feet high and 9 feet long, 50 feet from the end of the gallery, prevents any of the stemming from doing damage.

The tests in the gallery are witnessed from the Observation Room, a protected position about 60 feet from the gallery. The walls of the room are 18 inches thick and the line of vision passes through a ½ inch plate glass 6 inches wide and 37 feet long, and is further confined by two external guards, each 37 feet long and 3 feet wide.

When humidity tests are run on Gas and Dust Gallery No. 1. the apparatus is further equipped as follows: to the 14-inch doorway of section No. 1 is connected by suitable boxing a Koerting



GAS AND DUST GALLERY NO. 1, SHOWING CONSTRUCTION.

The upper view shows the concrete head, port holes and piping for gas on the side, and explosion doors on the top. An engineer is recording the pressure developed by an explosion of coal dust. The lower view shows the concrete base, piping for gas on the right side, and part of the mixing system on the left.

exhauster of the capacity of 240,000 cubic feet of free air per hour. No. 15 doorway is used as the air inlet, and to it are connected by suitable wooden boxes a compartment that contains steam radiators and the humidifiers. Three 38-inch triple-column radiators (two 23 panels and one 16 panel), averaging 310 square feet of heating

GENERAL VIEW OF GAS AND DUST GALLERY NO. I.

surface, are arranged with valves to control the quantity of steam flowing through them and are enclosed in a tight wooden box, approximately 2 feet 10½ inches by 3 feet 7 inches by 5 feet 5 inches. The air enters this box through a rectangular hole 10 by 12 inches in the end of the box, also through 25 round holes 2 inches in diameter. A baffle board 12 by 19½ inches is set inside the box opposite the large opening to distribute the current of air more evenly over the surface of the radiators. The air leaves this warming box through an 11¾ by 30-inch opening and is carried upward by suitable boxing to a compartment 3 feet 8¼ inches by 12 inches by 14 feet 2½ inches, which contains the humidifier heads. From here it goes through No. 15 doorway in the top of the gallery; the end of the gallery being efficiently closed by brattice cloth and paper diaphragms.

2.—Ballistic Pendulum.

The Ballistic Pendulum is for the purpose of measuring the unit disruptive force of various explosives. The unit disruptive force of explosives thus tested is defined to be the force required to swing the pendulum an amount equal to a swing produced by a charge of ½ pound of 40 per cent nitro-glycerine dynamite, used as a standard.

The apparatus consists essentially of a mortar weighing 31,600 pounds, suspended on knife edges, and a steel cannon mounted on a truck on a track, which is laid parallel with the direction of the swing of the mortar and which, at the time of firing, may be placed 1-16 of an inch from the muzzle of the mortar. The mortar is suspended from a beam supported by concrete walls 139 inches high, 51 by 120 inches at the base. On top of each wall is a base plate anchored to the wall. The knife edges rest on bearing plates placed on top of these base plates. Each bearing plate is provided with a small groove for the purpose of keeping the knife edges in oil and pro-

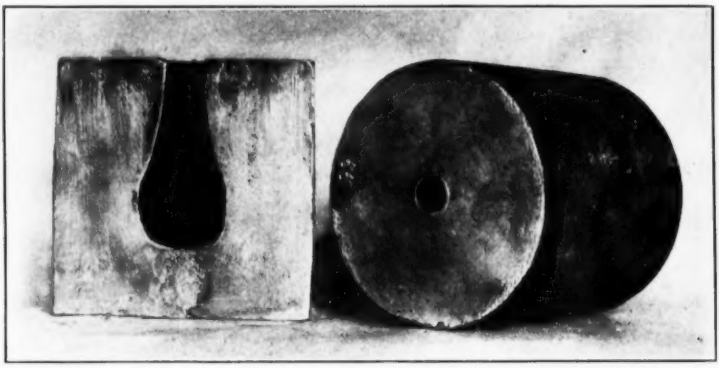
tecting them from the weather. Each knife edge is 6 inches long and the bearing surface is rounded to conform to a radius of ¼ inch. The mortar rests on two U-shaped saddles which pass through heavy steel castings bolted to the beam. The vertical distance from the point of the knife edges to the center of the trunnions of the mortar is 89¾ inches.

The cannons used on the truck are similar in size and material to those used in Gas and Dust Gallery No. 1. The truck consists of four wheels set to a 30-inch gauge, and the track extends about 9 feet from muzzle of mortar to bumper.

The shot is fired from the first floor of Building No. 17, about 10 yards from the pendulum, by means of an electric firing battery. The man who charges the cannon carries a safety plug from a stage switch when working and is thus protected in the same manner as the charger at Gas and Dust Gallery No. 1.

BALLISTIC PENDULUM FOR MEASURING DISRUPTIVE FORCE OF AN EXPLOSIVE.

A recording device is placed at the back of the mortar, which is connected to the mortar by means of a horizontal rod at the end of which is a circular face. A lug inserted in the bottom of the mortar directly below its center of gravity pushes this rod, transmitting the length of the swing to a scale at the other end of the rod, which by means of a vernier records the length of swing to the 1-200 part of an inch.



TRAUZL LEAD BLOCKS FOR MEASURING THE DISRUPTIVE FORCE OF AN EXPLOSIVE.
That at the left is cut through to show the cavity produced by explosion.

3.—Trauzl Lead Blocks

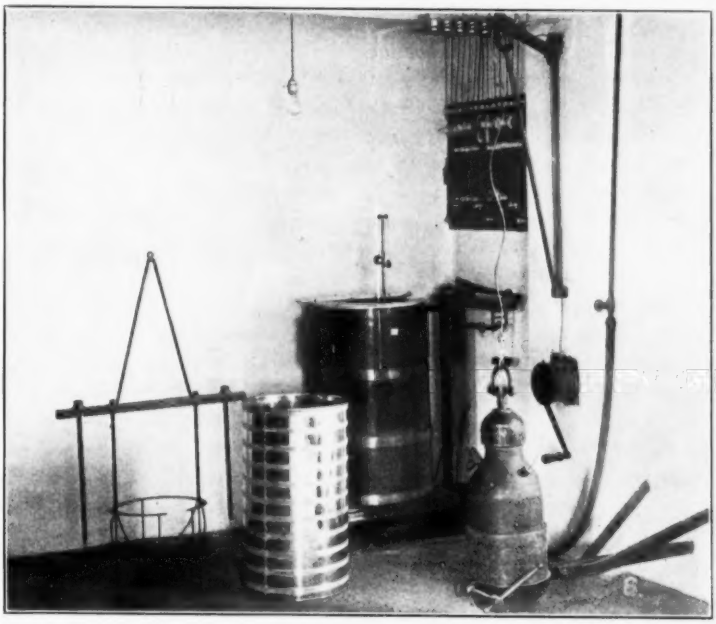
The Trauzl Lead Block Test is the method adopted by the Fifth International Congress of Applied Chemistry as standard for measuring the unit disruptive force of explosives. The unit disruptive force of explosives thus tested is defined to be the force required to enlarge the bore hole in the block an amount equivalent to that produced by 10 grammes of standard 40 per cent nitro-glycerine dynamite and stemmed with 50 grammes of dry sand under standard conditions as produced with a tamping device. The results of these tests when compared with those of the Bichel gauge indicate that for explosives of high detonation the lead block is quite accurate, but for slow explosives the expansion of the gas is not fast enough to make comparative results of value, the gases escaping from the bore hole of the block rather than taking effect in expanding the bore hole.

The lead blocks are cylindrical in shape, 200 millimetres in diameter and 200 millimetres high. Each has a central cavity, cylindrical in shape, 25 millimetres in diameter and 125 millimetres deep, in which the charge is placed. The blocks are made of desilverized lead of the best quality and as nearly as possible under identical conditions. The charge is placed in the cavity and prepared for detonation with an electric exploder and stemming. The yoke is not used and no additional attempt is made to confine the charge further. The bore hole after the explosion is pear-shaped, the size of the cavity depending not only upon the disruptive power of the explosive, but also upon its rate of detonation, as described above.

The size of the bore hole is measured by running in water from a burette until the cavity is just full, the difference between the size of the cavity originally and after detonation being of course the enlargement produced by the explosion.

5.—Calorimeter

The Explosion Calorimeter is designed to measure the quantity of heat given off by detonation of explosive charges of 100 grammes. The apparatus consists of a calorimeter bomb, the inner receiver or immersion vessel and wooden tub, a registering thermometer and a hooking frame. This piece of apparatus stands on the first floor in the east end of Building No 17.



CALORIMETER USED IN MEASURING HEAT OF DETONATION OF AN EXPLOSIVE.
Stirrer, jacket, tub, bomb, and winch for handling bomb.

The bomb is bottle-shaped, of ½-inch wrought steel, and has a capacity of 30 litres. On opposite sides near the top are bored apertures, one for the exhaust valve, for obtaining a partial vacuum, or about 10 millimetres of mercury column, after the bomb has been charged; the other for inserting the insulated plug through which passes the fuse wire for igniting the charge. The bomb is closed

with a cap, by means of which the chamber may be made absolutely air-tight. The bomb weighs 158 pounds, is 30 inches high with cap on, and is handled to and from the immersion vessel by means of a small crane.

The inner receiver is 30⅞ inches deep, 17⅞ inches inner diameter, and is made of 1-16-inch sheet copper nickel-plated, and strengthened on the outside with bands of copper wire. The outer tub is 30 inches deep, 21 inches inner diameter, is made of 1-inch lumber, and is strengthened with four brass hoops on the outside.

The stirring device consists of a small wooden beam connected to a system of three rings, having a horizontal bearing surface, and is operated vertically by means of a worm-gear run by an electric motor. When the apparatus is put together the inner receiver rests on a small standard on top of the base of the outer tank. The rings of the stirring device run between the bomb and the inner receiver. The bomb itself rests on a small standard placed on the bottom of the inner receiver. The apparaus is provided with a snugly-fitting board cover.

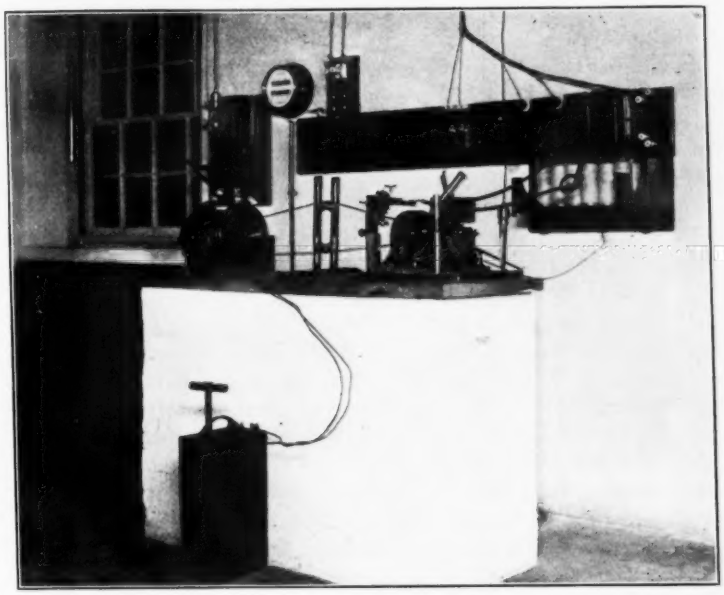
The rise in temperature of the water is read from a Centigrade thermometer measuring to the one-hundredth part of a degree. The height of the mercury column is read by means of a magnifying glass.

The bomb is charged from the top, the explosive being suspended in the center. The caps are then screwed on and the apparatus set together as above described, first, however, exhausting the air to the desired degree of rarification.

The apparatus is assembled on scales and the weight taken before the water is poured in, and then the weight with the water in the receiver. By obtaining the weight of the water in this way and knowing the temperature, the calorific value may be computed. The capacity of the inner receiver is about 70 litres. The charge is exploded by electricity while the water is being stirred. By combining the quantity of heat of the explosive in calories with the specific heats of the products of combustion at the proper temperatures, the maximum temperature of explosion may be arrived at.

6.—Rate-of-Detonation Apparatus

This apparatus is used to determine the velocity with which detonation travels through a given length of an explosive. For this purpose the explosive is placed in a long galvanized-iron tube 38 millimetres in diameter and 1.22 metres in length, and suspended in a pit provided for the purpose just outside of Building No. 17.



METTEGANG'S RECORDER FOR DETERMINING SPEED OF DETONATION OF AN EXPLOSIVE.
Recorder at right, motor at left, tachometer on wall back of motor.

This pit is 11 feet deep, 16 feet in diameter, and is provided with a steel-plate casing backed by a cushion of sawdust and provided with a heavy cover consisting of large timbers, covered by reinforced concrete, and anchored to the ground with eight dead-men. By means of electrical connections at each end of the tube, connected to the recording device known as Mettegang's recorder, placed in Building No. 17, the interval of time elapsing between detonation at the two ends of the tube is accurately measured on a smoked drum revolving with a known peripheral speed. In using such small lengths of explosive as one metre it is obviously essential that very minute differences in time shall be recorded. This recording device is conveniently equipped in such a way that a one-hundredth part of a millimetre may be measured. The drum is 500 millimetres in circumference and its normal speed is 86 revolutions per second. The smallest time interval that can be measured therefore is 1/4,300,000 of a second. The sticks of explosive, after cutting off their ends, are placed end to end, the length of explosive used being generally one metre.

7.—Flame-Test Apparatus.

This apparatus was designed for measuring the length and duration of flame given off by explosives. It consists essentially of a cannon, a photographic instrument, and a drum geared for high speed, to which a sensitized film may be fastened. The apparatus is placed at the northeast corner of Building No. 17. About 13 feet from the outside wall of the building is set the foundation for the cannon and encasing cylinder or shell. Set on top of this is a cannon identical with the one used for the Gas and Dust Gallery No. 1, the details of which are included in the description of that apparatus. The shell or cylinder is set on top of the concrete, concentric with the cannon, and is 43 inches internal diameter, 20 feet high, constructed of ¼-inch boiler plate in 24 sections and made absolutely light-tight on the side and base. Connecting this with a dark room in Building No. 17 is a light-tight conduit of rectangular cross section, 12 inches wide inside, horizontal on the bottom, sloping on the top from a height at the cylinder of 8 feet 3 inches to 21 inches at the inside of the wall of the building. It is carefully insulated from light by means of oakum packing at the joints in the building, and when not in use two small steel doors isolate the dark room from the light leaking from the top of the shell. The conduit is riveted to the

BUILDING NO. 17, U. S. GEOLOGICAL SURVEY TESTING STATION, PITTSBURG, PA.

Pit for speed-of-detonation determinations at left. Stack and conduit of flame-test apparatus at right.

shell. A vertical slit 2 inches wide and 8 feet long is cut in the shell coincident with the center lines of the conduit. A vertical plane drawn through the center line of the bore hole of the cannon and of this slit intersects the center line of the quartz lens, the center of the stenopaic slit immediately in front of the film, and the axis of the drum on which the film revolves. The photographic apparatus consists of a shutter; a quartz lens placed in such a position as to focus the rays of light, including the ultra-violet rays (which are those attending extreme heat); a stenopaic slit between the lens and the rotary drum, 76 millimetres long and 1.7 millimetres wide; a rotary drum 50 centimetres in circumference and 10 centimetres deep, geared to and driven by a 220-volt motor, which is connected to a tachometer reading in both metres per second and revolutions per minute. A maximum peripheral speed of the drum of 20 metres per second may be obtained. The speed is regulated by a rheostat. The drum, gears, shutter, lens, stenopaic slit, and connecting apparatus, are enclosed in a light-tight box for convenience so that the film may be left on the drum in position should the operator desire to leave the dark room.

One hundred grammes of the explosive is used in the cannon and the firing line extends from the cannon to the dark room, from which place the shot is fired. The firing line is equipped with a stage switch as a precaution.

With the drum at rest the flame is shown on the film as a vertical line of a width equal to the stenopaic slit, and by simple proportion the exact height of the flame may be determined. When the drum is in rapid motion of known velocity, not only the height of flame but the duration may be computed by measuring the lateral displacement on the film and applying it to the known peripheral speed.

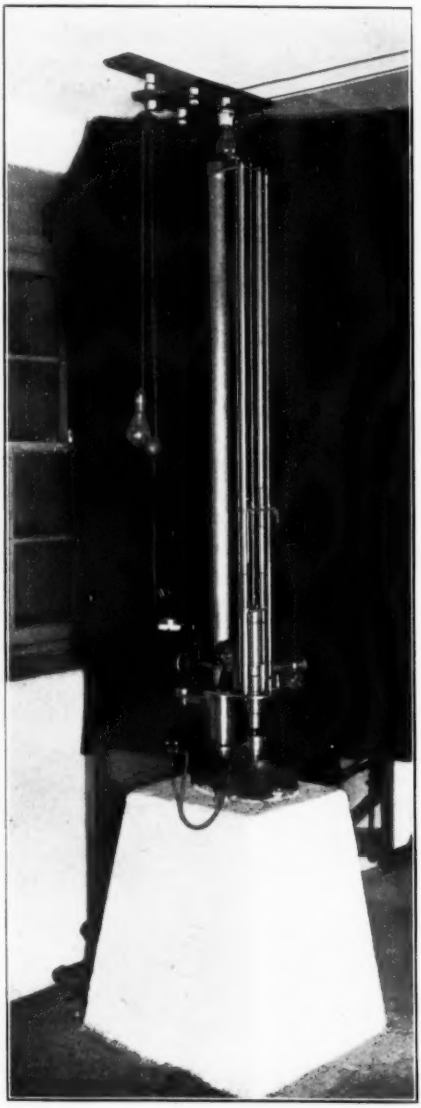
8.—Impact Machine.

The Impact Machine is designed to determine the sensitiveness of an explosive to shock. For this purpose a drop hammer is used constructed in such a way as to meet the following requirements: (1), a substantial unyielding foundation of constant temperature; (2), minimum friction in the guide grooves so as to approximate the conditions of a freely falling body; (3), prevention of escape or scattering of the explosive when struck by the falling weight.

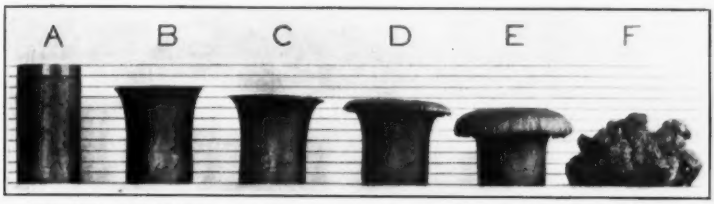
The apparatus consists essentially of the following parts: an endless chain working in a vertical path, operated by electricity and provided with two lugs equally spaced; a steel anvil upon which the charge of explosive is placed; a steel stamp pressing on top of the charge, holding it in position; a magnetizing collar operating freely

in vertical guides and provided with small jaws in the rear, so placed that the lugs of the chain engage them; a steel weight which operates loosely in vertical guides and is drawn by the magnetizing collar to determinable heights when the machine is in operation; a demagnetizing collar which may be set at known heights and which is provided with a release for the jaws of the first collar, and recording device geared to a vertically driven threaded rod which sets the demagnetizing device and thus determines the height of fall of the weights.

The apparatus is supported by a concrete pedestal which is set at a convenient height for the operator. The heavy oval-shaped steel base of the machine itself is anchor-bolted to this pedestal, and into the base is screwed the anvil on which the charge of explosive is placed. The main standard of the apparatus is about 65 inches high and 2¼ inches diameter, shrunk into a flanged collar which is screwed into the base plate at the rear. The collar guides are ⅝-inch



IMPACT APPARATUS FOR DETERMINING SENSITIVENESS OF AN EXPLOSIVE TO SHOCK.



SMALL LEAD BLOCKS FOR DETERMINING THE QUICKNESS OF AN EXPLOSIVE.
A, block with steel cap. B, C, D, E, blocks after detonation of "safety" explosives.
F, block after detonation of 40 per cent dynamite.

rods, extending from a plate securely fastened to the top of the flanged collar at the base of the main standard to the plate of the apparatus. The steel stamp which transmits the blow of the fallen weight is 7½ inches high, 1 2/16 inches in diameter, tapered at the base to a small cylinder ⅜ inches high and ⅜ inches in diameter, which operates at the center of the anvil. The drop hammer weighs 2,000 grammes, and moves in loose fitting guides which produce a minimum of friction. The hammer is dropped from varying heights until detonation takes place. A maximum safety height is determined when five attempts to explode a charge fail at that height, and if five or less attempts at that height, plus 1 centimetre, give at least one explosion.

Care is taken that the anvil and stamp are well cleaned after each test. The whole apparatus when not in use is covered with oil and provided with a hood. In order to maintain a uniform temperature while experimenting, water at a temperature of 25 degrees Centigrade flows through the anvil.

9.—THE EXPLOSION-BY-INFLUENCE TESTS.

For this test the pit described above under (6) is used, and two sticks of each explosive are required. The sticks are placed end to end, separated by a certain distance, always a multiple of one inch, and the pair suspended in a vertical position. The lower stick is detonated, and the upper stick either is or is not detonated, depending upon the distance between the sticks and the sensitiveness of the explosive to the other by influence. The maximum distance of explosion by influence is established if the second stick explodes at that distance and fails to explode three times at that distance plus one inch.

10.—RATE OF BURNING SLOW EXPLOSIVES.

This test is performed in the pit described under (6) and the explosive is placed in a hydraulic pipe having an inside diameter of 1½ inches. One end of this pipe is closed with a plug, the other end

being free. The fuse is placed in the free end and the explosive burns toward the plug end. Insulated annunciator wires are placed through by sparks on the Mettegang's recorder, but the time interval between by sparks on the Mettergang's recorder, but the time interval between the sparks is taken by means of a stop watch.

Care is taken that the density of the explosive is normal.

11.—Bichel Pressure Gauges.

These gauges are used for determining the strength of explosives, by measuring pressure developed in a space so enclosed that the escape of generated gases is rendered impossible. The apparatus consists of a stout steel cylinder which may be made absolutely air-tight, an air pump and proper connections for exhausting the air in the cylinder to a pressure of 10 millimetres of mercury, an insulated plug for providing the means to ignite the charge, a valve by means of which the gaseous products of combustion may be removed for subsequent analysis, an indicator and drum, with proper connection for driving it at a known speed.

The apparatus is installed in the southeast corner of Building No. 17. The cylinder rests on a solid footing at a convenient height for handling. It is 31½ inches long, 19¾ inches diameter, and anchored to the footing. The explosion chamber is 19 inches long and 17⅞ inches in diameter, having a capacty of exactly 15 litres. The cover of the cylinder is a heavy piece of steel held in place by heavy steel studs and nuts and a yoke.

The charge is placed on a small wire tripod, and connections are made with a fuse to an electric firing battery for igniting the charge. A near-vacuum is produced by means of an air pump in order to approach more nearly the conditions of a tamped charged exploding in a bore hole inaccessible to air. When the charge is exploded a record is made on the indicator card, and is a rapidly ascending curve for quick explosives, grading into a shallower curve, slowly rising, for explosives of slow detonation. When the gases cool, the curve merges into a straight line, which indicates the pressure of the coolest gases on the sides of the chamber.

Since the volume of the chamber is nearly 75 times that of the charge, the pressure of the charge confined in its own volume may also be found. The cooling influence of the inner surface upon the gaseous products of combustion is a vital point in computing the pressure developed by an explosive. Its effect is eliminated by comparing the pressures obtained in the original cylinder with those of a second cylinder of larger capacity, into which have been inserted one

or more steel cylinders, thus increasing the superficial area while keeping the volume constant. By comparing the effect of the increased cooling surface with the original, a curve may be plotted which will determine the actual pressure developed after the elimination of the surface influence.

12.—Black-Powder Separator.

The separator is made similar to the separators used in powder mills, but of reduced size. It consists of an inclined box provided with slots on the sides to carry a series of screens, and a vertical conduit at the end for carrying off the screened products into different small bins standing on each side of the apparatus. At the upper end of the screens is a small hopper with a sliding brass apron to cut off the feed. The screens are shaken laterally by means of an eccentric rod operating by hand. The inclined box is 6 feet 10 inches long from tip to tip and set at an angle of 9 degrees with the horizontal. The grains after separation fall 24 inches through the vertical conduit, thence passing on to the bins through small zinc chutes 1 inch by 2 inches in section.

The apparatus is supported by wooden framework and care has been exercised to have no steel nor iron exposed to the powder. The screens are held by light wooden frames which slip into the inclined box from the upper end. In this way any or all screens may be used at once, thus separating all grades or making only such separations as are desired. The screens with the largest meshes are diagonally perforated zinc plates; the finer meshes are obtained by silk screens.

Zinc Plates. (Circular Holes).

Diameter of Holes. inches.	Number of Holes. per square foot.
1/2	353
4/10	518
1/3	782
1/4	1,392
1/5	1,680
1/8	3,456
1/10	6,636
1/16	12,800

Silk Screens, (Square Holes).

Dimensions of Holes, inches.

1/20 x 1/20
1/28 x 1/28

Up to a few years ago black blasting powder was manufactured in the following sizes:

CC	from	2	to	2½	mesh
C	"	2½	"	3	"
F	"	3	"	5	"
FF	"	5	"	8	"
FFF	"	8	"	16	"
FFFF	"	16	"	28	"

In late years there has been quite a demand for special sizes and mixed grains for individual mines, especially in the State of Illinois. As there has not been any material change in the brands, the letters as now used are not indicative of the size of grains they are supposed to represent.

Twenty-nine samples of black blasting powder were recently received from the Illinois Powder Commission. This Commission is composed of three miners and three operators, and its object is to settle all disputes that may arise between the miners and operators in regard to the kind of powder used. Of the twenty-nine samples submitted, only ten contained 95 per cent. of the size of grains they were supposed to represent; four contained 90 per cent.; seven varied from 80 to 90 per cent.; several others were mixtures of small and large grains and were branded (FF) black blasting powder, while one contained only 8 5/10 per cent. of the size of grain it was supposed to represent, and the remaining samples showed many variations even when sold under the same name.

This practice is exceedingly dangerous, for the reason that a miner after becoming accustomed to the use of one brand of (FF) powder of uniform separation, receives another make of similar brand but of mixed grains, and the consequence is he cannot gauge the amount of powder to be used. The result is often an overload or a blown-out shot, while at the same time the smaller grains will burn first and the larger ones may be thrown out before the combustion is complete. It has been suggested by the Illinois Powder Commission that a committee of powder manufacturers and the Illinois Powder Commission meet at the United States Testing Station at Pittsburg and discuss this question. It is believed that the powder manufacturers would welcome a universal classification of grains.

After an extended series of tests had been completed under various conditions for the purpose of standardizing and calibrating the apparatus, a series of tests requirements has been established to which explosives submitted for test shall be subjected, as follows:

The tests will be made by the engineers of the United States Explosives Testing Station at Pittsburg, Pa., in Gas and Dust Gallery No. 1. The charge of explosive to be fired in tests Nos. 1, 2 and 3 shall be equal in disruptive power to one-half pound of nitro-glycerine dynamite in its original wrapper, of the following formula:

	per cent.
Nitro-glycerine	40
Nitrate of sodium	44
Wood pulp	15
Calcium carbonate	1
	100

Each shot shall be fired with an electric fuse of sufficient power to detonate or explode the charge completely, as recommended by the manufacturer. The explosives must be in such condition that the chemical and physical tests do not show any unfavorable results. The explosives in which the charge used is less than 100 grammes will be weighed in tin foil without the original wrapper.

The dust used in test Nos. 2, 3, 4, and 5 will be of same degree of fineness and taken from one mine.

Test 1.—Ten shots with the charge as described above, in the original wrapper, shall be fired, each with 1 pound of clay tamping, at a gallery temperature of 77 degrees Fahrenheit, into a mixture of gas and air containing 8 per cent. of methane and ethane. An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 2.—Ten shots with charge as previously noted, in its original wrapper, shall be fired, each with 1 pound of clay tamping, at a gallery temperature of 77 degrees Fahrenheit, into a mixture of gas and air containing 4 per cent. of methane and ethane and 20 pounds of coal dust, 18 pounds of which is to be placed on shelves laterally arranged along the first 20 feet of the gallery, and 2 pounds to be placed near the inlet of the mixing system in such a manner that all or part of it will become suspended in the first division of the gallery. An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 3.—Ten shots with charge as previously noted, in its original wrapper, shall be fired, each with 1 pound of clay tamping, at a gallery temperature of 77 degrees Fahrenheit, into 40 pounds of bituminous coal dust, 20 pounds of which is to be distributed uniformly on a horse placed in front of the cannon and 20 pounds placed on side shelves in sections 4, 5 and 6. An explosive will pass this test if all ten shots fail to ignite the mixture.

Test 4.—A limit charge will be determined within 25 grammes by firing charges in their original wrappers unstemmed at a gallery temperature of 77 degrees Fahrenheit, into a mixture of gas and air containing 4 per cent. of methane and ethane and 20 pounds of bituminous coal dust, to be arranged in the same manner as in Test 2. This limit charge is to be repeated five times under the same conditions before being established.

Test 5.—A limit charge will be determined under the same conditions as in test 4, except that 2 per cent. of methane and ethane will be used instead of 4 per cent.

Up to the present time we have completed tests on twenty-nine different explosives, seventeen of which have passed all tests.

NOTE.—At least two pounds of clay stemming will be used with slow-burning explosives.

It has been found that the permissible explosives having a nitroglycerine base have the highest limit charges, and that the average permissible explosive produces about the same amount of inflammable gases as ordinary black blasting powder when charges equal in disruptive force are compared. From the results of our tests it is my opinion that several of the permissible explosives, if properly used, would produce as good a quality of coal as black powder.

Several hundred tests have been made with black blasting powder in the presence of bituminous coal dust and in every case an ignition of the dust has occurred.

A series of tests has been commenced to determine the amount of moisture necessary with different coal dusts, to reduce the liability of a coal-dust explosion caused by a blown-out shot of one of the dangerous types of explosives. Coal dust taken from the roads of one of the coal mines in the Pittsburg district required at least 12 per cent. of water to prevent an ignition, under the conditions stated above. It has also been proven that the finer the dust the more water is required, and dust of 100-mesh fine necessitated 30 per cent of water to prevent an ignition when the flame of a blown-out shot is in direct contact with the dust.

The usual methods, now employed in sprinkling, have proven entirely insufficient to moisten the dust thoroughly and are unreliable as far as a prevention of a general dust explosion is concerned.

At this station successful experiments have been carried out by using humidifiers to moisten the atmosphere after the temperature of the air outside the gallery has been raised to a mine temperature and drawn through the humidifiers. It has been found that if a relative humidity of 90 per cent, at a temperature of 60 degrees Fahrenheit, is maintained for 48 hours, a simulation of the summer conditions in a mine, the absorption of moisture by the dust and the blanketing effect of the humid air prevented a general ignition of the dust.

Humidifiers have been used in all tests so far made for the purpose of raising the percentage of relative humidity, but it is very evident that steam or other spraying devices would be equally effective. It is unquestionable that many mines could be successfully and advantageously equipped with spraying devices, but in some cases it may not be practical, because of an insufficient supply of fairly good water. It is expected that the results obtained at the testing station will be supplemented under actual working conditions in the mines. The contention, lately pointed out, as to the disadvantages of spraying, due to increase in falls, can be definitely determined and weighed against the advantages given by the protection from dust explosions.

SMOKE PREVENTION OR SMOKE CONSUMPTION.

By Harold V. Coes.

A preceding article by Mr. Coes has outlined the causes of smoke and the principles of smokeless combustion, and has reviewed the methods and devices employed to prevent or diminish smoke in hand-fired boiler plants. The present instalment classifies and discusses automatic stokers, describing the leading types of apparatus in the various classes, with an estimate of their usefulness in solving the problems of smoke prevention. A brief concluding article, to follow next month, will deal with the choice of apparatus to burn the various grades of coal, the design of boiler furnaces, and the economy of mechanical over hand firing.—THE EDITORS.

THE automatic stoker is the product of effort to cure the many defects of hand firing. In order to get the best results from a steam-boiler furnace, the firing should be as constant and regular as possible, so that the chemical action may continue undisturbed. Hand firing, from its very nature, must of necessity be intermittent and therefore irregular. When the rate of combustion is high and the boiler is steaming rapidly, it is not conducive to the highest economy or the suppression of smoke to allow the opening of the fire-doors to admit a fresh charge of fuel, thus allowing cold air, often far below the freezing point, to impinge against the heated surfaces and tubes of the boiler, at the same time lowering the temperature of the gases in the furnaces; and allowing the deadening of the fire by a heavy charge of fresh green fuel, almost always in excess of the actual requirements, and too often unevenly and carelessly spread.

Mechanical stokers have been used in England since 1785. In that year one was patented by James Watt. It was simply a device for pushing the coal, after it was coked, back toward the bridge wall, and was designed to meet the smoke-law requirements of that date. One type of stoker was patented by John Jukes in 1841, and another by E. Henderson in 1843. The Jukes stoker consisted of grate-bars connected by pins and links to form an endless chain, the grate-bars running perpendicular to the plane of rotation. The coal was fed into the chain grate by a hopper, the method of operation being similar to that of modern chain-grate stokers. The Henderson stoker consisted of two horizontal fans, revolving on vertical spindles, which scattered or sprayed the fuel over the fire. Needless to say, this was not very satisfactory.

The first distinctively American stoker was brought out in 1878 by Thomas Murphy, of Detroit, Mich. Mr. Murphy was a marine engineer, and the first installations he made were in connection with marine boilers on Lake tug-boats. One such installation was carefully tested by B. F. Isherwood, Engineer in Chief of the U. S. Navy, who recommended that several of the naval steamers be fitted with Murphy grates, in his report to the Navy Department giving particulars of these trials. He was unable, however, to secure an appropriation, and although his reports indicate that marine boilers could be stoked mechanically with considerable economy, the mechanical stoker has reached its highest development in connection with stationary boilers.

An automatic stoker, in its simplest form, is merely a perfect, tireless fireman. The claim is frequently made, by men of unquestioned engineering ability, that automatic stokers cannot improve on the results obtained by an expert fireman, whereas experience shows that the results always bear a fixed relation to the quality of the firing; in other words, it depends upon the personal equation. An automatic stoker eliminates the personal equation, and furthermore accomplishes five results that cannot possibly be attained with hand-firing conditions. In the first place, it introduces coal into the furnace without admitting cold air over the fire to chill the gases, lower the efficiency, and start leaky tubes by unequal expansion; second, it burns the coal in such a way that the volatile gases are thoroughly consumed, thereby utilizing the highest possible percentage of the heat of combustion with a correspondingly increased efficiency; third, it keeps the fire automatically sliced without admitting cold air to the furnace with the results stated above; fourth, if properly designed, it allows the fire to be cleaned while the stoker is in operation without admitting cold air or decreasing the furnace temperature or lowering the efficiency in any way; lastly, if properly designed, it controls the amount of air and coal in such a way that they always bear a fixed relation to each other irrespective of the rating at which the boiler is being operated. This last accomplishment of the automatic stoker is a most important factor in the economy of operation of the plant, as it guarantees a practically constant efficiency throughout the entire range of operation and for nearly any length of time.

It is absolutely necessary, however, that the design of a stoker be suited to the quality and the quantity of the coal to be burned per square foot of grate surface per hour. The stoker should distribute the fuel in such a manner that it will be economically burned; it must admit a proper supply of air at the right place to insure perfect

combustion; it should allow the examination of the fire at all times and the stirring and slicing of it when necessary; it must permit, when in actual operation, the ready removal of clinker from the grate-bars and of ashes from the fire without carrying combustible matter along, and without breaking up the fire. The parts should be few and free from all complications, and easily and quickly replaceable; all moving parts should be protected from the heat and action of the fire. The stoker should be installed in a furnace of sufficient size, with a fire-brick roof when necessary and means for preheating the air if possible.

Mechanical stokers, or methods for the automatic firing of fuel, may be divided into three distinct classes:—

1.—The "overfeed",

2.—The "underfeed",

3.—The pulverized or injected fuel.

These classes may again be sub-divided into types:—

a. The forwardly inclined grate of which the "Roney" stoker is the most typical example,

b. The V-shaped grate, of which the Murphy is the leading type. (Both of these stokers are "overfeed").

c. The "underfeed" stoker, the Jones and the Taylor being the most characteristic examples of this type.

d. The chain grate, of which the Green is the leading representative.

There are a number of successful applications of the principles represented by each of these types, and there are records of successful performance of installations of many variations of each type. While each has its special feature of excellence, some installations and conditions are better suited to one class and type and some to another.

In describing the first type, the Roney stoker will be used as an example. The overfeed stoker receives its name from the method employed for firing the fuel into the furnace, the method of operation being as follows: (See Figure 1.)

The coal is fed onto the inclined grate from the hopper by a reciprocating platen or pusher, which is actuated by the agitator rocker arm and the agitator sector. These derive their motion through the eccentric from the driving shaft attached, under the hopper, to the stoker front. The grate bars rock through an arc of about 30 degrees, assuming alternately the stepped and inclined position. The grate bars receive their motion from the rocker bar and attached connecting rod, and these, together with the platen, are

FIG. 1. LATEST MODEL OF THE RONEY STOKER.

actuated by the agitator. The range of motion of the pusher is regulated by the feed wheel according to the desired length of stroke, the amount of coal fed into the furnace being governed by the load on the boiler. The motion of the grate bars is also controlled by the position of the sheath nut and lock nuts on the connecting rod. Each grate bar is composed of two parts, a vertical web and a sectional corrugated fuel plate which bolts to the web. These grates or fuel plates carry the bed of burning fuel, and being wearing and burning parts, they are made detachable, thus reducing the cost of repairs to these parts to a minimum. The webs are perforated with longitudinal slots, so placed that the condition of the fire can be seen at all times without opening the fire doors. These slots also serve to conduct air to the fuel for combustion. The stoker is provided with a coal guard, which is raised, and prevents the coal from sliding or avalanching when the dumping grate is dropped to discharge clinker and ash. On resetting the dumping grates, the guard is dropped to normal position. (Figure 2).

The processes of combustion take place as follows:—

The fuel having been introduced into the hopper at the front of the boiler, either by hand or by coal-handling machinery, is forced onto the inclined grates by the platen or pusher. The coal then passes through an opening in the front of the boiler and directly back of the hopper, under a fire-brick coking arch which extends across the boiler. Here the fuel is distilled, giving off its volatile matter and becoming thoroughly coked. It next passes onto the inclined grates, and is alternately stepped up and inclined downward by the fuel plates in its passage over the grates to the dumping grates, where it is supposedly reduced to a mixture of coke, ash, clinker, and inert matter.

The principal advantages of the Roney stoker are:—

1.—Its commercial flexibility; that is, the ability to meet sudden changes in commercial loads such as occur in electric-light and power and railroad work, for it can be quickly fired and the fire can be sliced and stirred by hand when necessary.

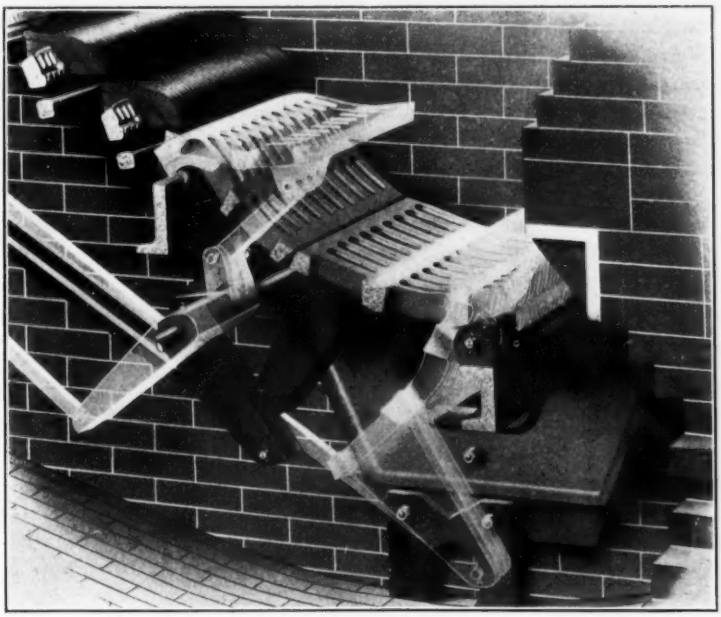


FIG. 2. COAL GUARD DUMP PLATE, LATEST FORM OF RONEY STOKER.

The "ghost" view shows the fuel plate in dumping position, with guard raised to prevent fuel avalanching.

2.—The dumping grates are placed at the rear of the furnace in front of the bridge wall, and can be operated without interfering with the action of the stoker or the boiler.

3.—The entire fuel bed is visible from the under side of the grate.

4.—On account of having two adjustments for feeding, the operation is easy for the ordinary fireman to understand.

5.—This stoker has the advantage of natural draft and is able to respond quickly by breaking up the fire.

Its principal disadvantages are:—

1.—With non-caking coal, the fuel bed is broken up or cracked parallel to the grate bars every time the grates are stepped up, thus allowing the cold air to run through with the consequent chilling of the gases resulting in smoke and decreased efficiency.

2.—With the coal running high in sulphur (or iron pyrites) forming a slagging clinker, sloughing away of the grate bars and fuel plates cannot be prevented.

3.—With a stoker of this type, using moving grate bars, loss of fine fuel by filtration through the grates cannot be prevented, consequently the ash runs high in combustible matter.

4.—The stoker consists of numerous moving parts, some of which are subjected to the heat of the furnace either by direct contact or by radiation, and this of course means rapid deterioration.

5.—Owing to the fact that it is operated under natural draft, the stoker is unable to meet very excessive overloads which are sometimes demanded in railroad, electric-light, and power work and which can be obtained with forced draft.

6.—In the ordinary electric-light and power plant, as well as in the electric-railroad plant, the cost of maintenance is high on account of the rapid changes in load and method of operation.

7.—It is necessary to maintain an ignition and coking arch.

The latest type of Roney stoker, with its new finger-bar grates (See cut) is said to have eliminated many of the difficulties mentioned, such as sifting the fuel, cracking of the fire, and producing smoke. This improvement, successfully applied in several large plants, has increased the value of this stoker considerably. (Figues 3 and 4). If properly baffled, this stoker can be operated from 50 to 100 per cent capacity without smoke, on coals running fairly high in volatile matter, but above this it cannot be run without objectionable smoke, except by the careful operation of expert firemen.

The Murphy stoker has been chosen as an example of the V-shaped overfeed type, first, because it is the oldest American stoker; second, because, in my opinion, it is the most typical.

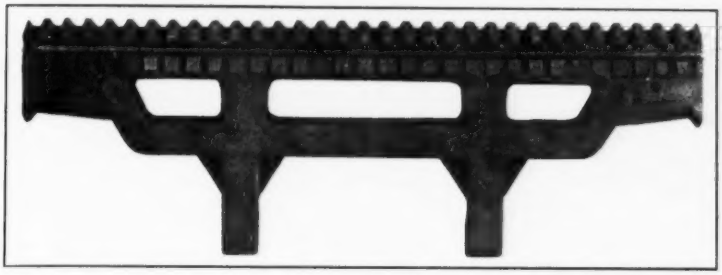


FIG. 3. GRATE BEARER, NEW MODEL RONEY STOKER.

The Murphy automatic smokeless furnace, as it is termed by its manufacturers, consists of two inclined grates arranged in the form of a V, the plane of the grates being perpendicular to the boiler front. (See Figure 5). At the top of these grates, extending from front to rear, are the coal magazines. In the bottom of each magazine is the pusher or platen, operated by segmental gear, shafts and racks, which are driven by connecting rods and links from the prime mover. The grates are made in pairs, one fixed, the other movable. The movable grates, hinged at the upper ends, are moved by a rocker bar at their lower ends alternately above and below the stationary grates. The stationary grates rest upon the grate bearer, which also contains the clinker grinder. The grate bearer contains a pipe which receives exhaust steam from the stoker engine; this steam, escaping through small openings at regular intervals on either side of the clinker grinder and lower ends of the grates, softens the

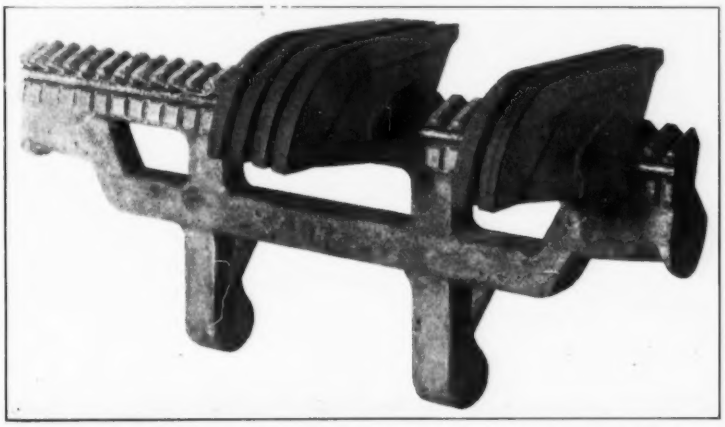


FIG. 4. RONEY STOKER GRATE BEARER AND REMOVABLE FINGER BARS.

clinker. The clinker grinder is also cast hollow, and is connected by a two-inch pipe to the flue. Cold air circulating through it prevents its destruction by heat (Figure 6). Over the coking plate is the arch plate, from which a fire-brick coking arch is sprung over the entire furnace. This arch plate is in the form of a grate, the segments of which form a series of air ducts immediately over the coking plate. The stoker is operated by a small automatic engine geared to a reciprocating bar which extends across the entire furnace front and to which are connected the links that operate the moving parts. (Figures 7 and 8).

In operation, the coal leaves the coal magazine and rests upon the coking arch for a certain period of time, this time interval depending upon the number of revolutions that the platen shaft is making. The volatile matter is driven off and mixed with preheated air from the ducts in the coking arch. The coal, having been coked, then travels down the inclined grates to the clinker grinder, receiving the air necessary for complete combustion through the grates. The refuse is then ground up and automatically discharged into the ash hoppers.

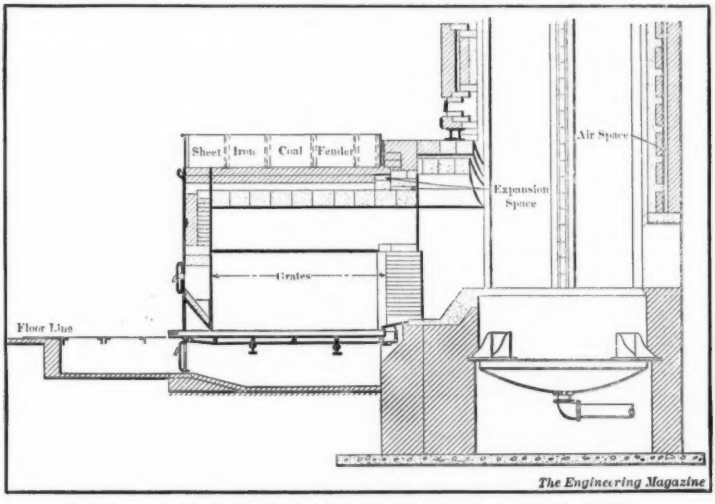


FIG. 5. MURPHY FURNACE ADAPTED TO WICKES VERTICAL BOILER.

The principal advantages of the Murphy stoker are:—

1.—The coal is thoroughly coked and the distilled hydrocarbons are mixed with a correct amount of preheated air, insuring good combustion and very little, if any, smoke.

2.—The stoker and the rate of feeding are always under control

and the clinker grinder can be regulated according to the amount of ash in the coal.

3.—The clinker grinders and fires and the ash-pit below are readily accessible while the stoker is in operation.

4.—Numerous poke holes are provided in the front, and any of the moving parts can be operated by hand if necessary while the stoker is in operation.

5.—The fires can be readily dumped and banked.

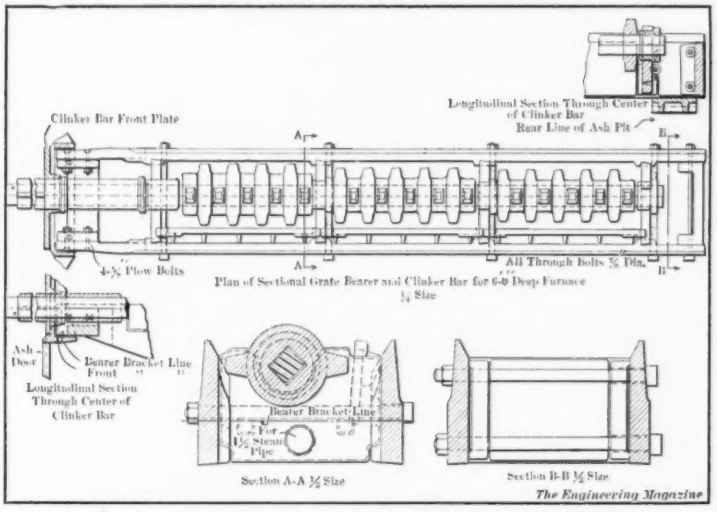

Longitudinal Section Through Center of Clinker Bar
Rear Line of Ash Pit
Clinker Bar Front Plate
A
B
4-¾ Plow Bolts
All Through Bolts ⅞ Dia.
Plan of Sectional Grate Bearer and Clinker Bar for 6-0 Deep Furnace
½ Size
Ash-Door
Bearer Bracket Line Front
Longitudinal Section Through Center of Clinker Bar
Bearer Bracket Line
For 1½ Steam Pipe
Section A-A ½ Size
Section B-B ½ Size
The Engineering Magazine

FIG. 6. BUILT-UP GRATE BEARER AND SECTIONAL TAPERED CLINKER BAR, MURPHY STOKER.

Some of the disadvantages are:—

1.—The inability to adapt it to a water-tube boiler with ordinary column spacing.

2.—The difficulty of getting an even distribution of the coal over the fire, from front to rear, when the magazine is fed by a gravity downtake under a low head. This trouble is really no fault of the stoker's and is merely poor plant design.

3.—The sticking, breaking off of fingers, and clogging up of the clinker grinder, when a coal is used which runs high in iron oxide and low in silicates, forming a low-melting, sticky clinker. With their new built-up grate bearer and sectional tapered clinker bar assembly, most of the above trouble can be prevented. This new clinker grinder is a decided improvement and materially reduces the cost of maintenance. If the coal runs high in sulphur, corrosion of the grates and clinker grinder can be expected.

FIG. 7. MURPHY STOKERS, BOILER HOUSE NO. 1, UNITED ELECTRIC LIGHT CO., SPRINGFIELD, MASS.
Four 300 horse-power and ten 400 horse-power Hazelton boilers.

4.—The liability of coking plate and coal magazine to burn. This fourth difficulty, however, is not apt to appear unless the stoker is carelessly handled, as the air for combustion blows the gases away from the ducts and magazines and no back-firing should occur when everything is operating properly.

5.—The sifting of fine coal through the grates.

The economy of operation of this stoker is high on account of the ability to coke the coal thoroughly and mix the products of combustion with finely divided streams of preheated air, and therefore to maintain a high temperature. Furthermore, the per cent of combustible matter in the ash is low when the clinker grinder is properly adjusted for speed according to the per cent of ash in the coal, and is operating satisfactorily.

The first underfeed stoker commercially practicable was the Jones. Engineers are of the opinion, or are rapidly changing to the opinion, that the only really scientific method of burning coal under a steam boiler with maximum economy is by the underfeed method.

The external parts of the "Jones" stoker consist essentially of a ram case, steam cylinder, and coal hopper. This external mechanism

occupies a floor space of about 4 feet 8½ inches by 16 inches in front of the boiler. The ram case is bolted to the retort at the junction with the boiler front and contains the ram or plunger by which the fuel is forced into the furnace upon its descent from the hopper.

The actuating mechanism is a steam cylinder, the piston movement of which is regulated by an automatic attachment. The attachment is placed on a stand in close proximity to the stokers it controls. The rotary valves admitting the steam to the cylinders are placed on this stand. The valves are driven by being belt-connected to the forced-draft blower furnishing the air for combustion, which blower is driven by an independent engine or motor—as the case may be—

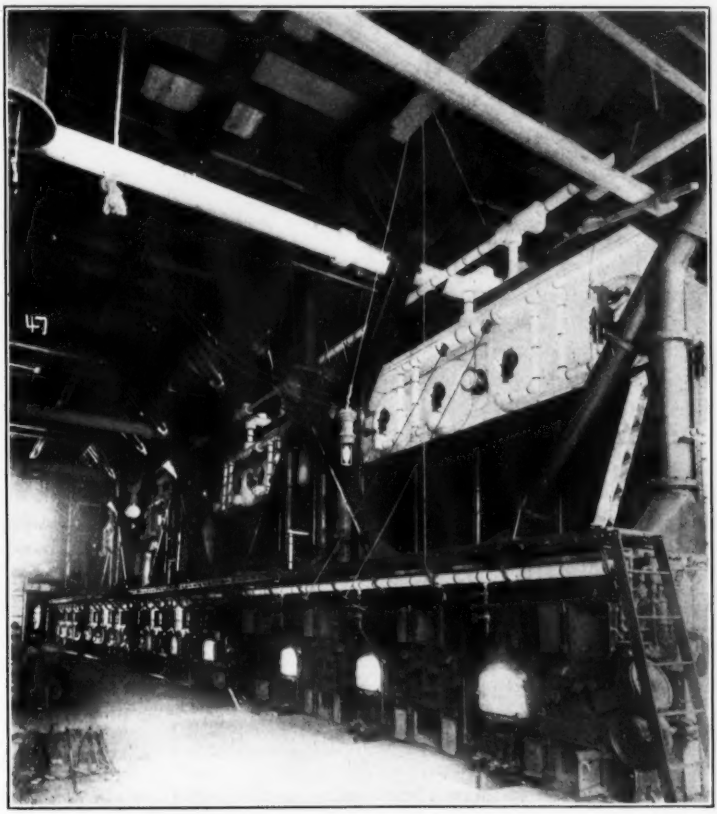


FIG. 8. MARKET STREET STATION, NEW ORLEANS RAILWAY & LIGHT CO.
Thirty-six Murphy stokers with twelve 900 horse-power B. & W. boilers.

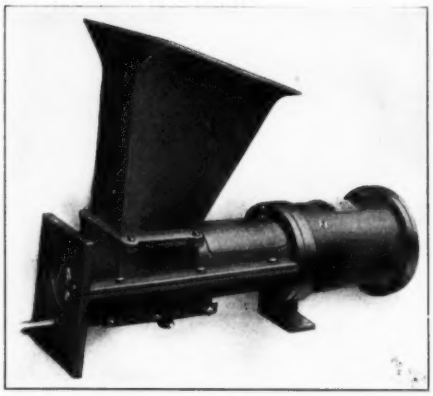


FIG. 9. JONES STOKER.
Under-Feed Stoker Company of America.

the speed of the engine or motor being regulated by means of a regulating valve or a steam-actuated controling device.

As steam rises or falls, the regulating valve or controlling device closes or opens the valve admitting steam to the engine. Thus the speed of the engine or motor is decreased or increased automatically, effecting a proper proportionment of the fuel and air supply. The parts inside the furnace consist of a retort or fuel magazine with tuyere blocks and auxiliary ram or plunger. The tuyeres are hollow cast-iron blocks weighing about 25 pounds each, and are designed as the medium for the air distribution for the fuel bed. They are secured to the retort by a rod running through eyes cast in the tuyere blocks.

The method of operation is radically different from the overfeed stokers. Coal is introduced into the hopper, either by hand or by a gravity system, where it is forced by the ram into the retort. The ram, as stated before, is steam-operated and controlled by one of the aforementioned devices. The ram, at each forward impulse, carries about 15 to 20 pounds of coal into the retort, where it is pushed up and carried along by the auxiliary ram, thus insuring an even distribution of the fuel. The effect of the auxiliary rams is to break up the entire fuel bed and to give the coal an upward and backward movement, thus forcing the clinker and non-combustible matter to the dead plates on either side of the retorts, whence it is removed at regular intervals. The length of time for cleaning, usually six to eight hours, is entirely dependent on the character of the coal and the rate of combustion. The stoker has to be cleaned and the fires pulled by hand, as there are no dumping plates or automatic dumping devices on this stoker. The method of handling and cleaning the fires is the same as with hand-fired non-dumping furnaces.

The underfeed stoker must of necessity be operated by forced draft. Air for combustion is obtained by a volume blower, driven either by an engine, turbine, line shafting, or by an electric motor,

and is delivered to the wind box under the furnace. There is a distinct advantage in using forced draft for combustion purposes. The air is preheated in its passage under the furnace and through the tuyeres, thus creating the most favorable conditions for effecting perfect combustion. Moreover, the operator has at his command the essential elements of economic and smokeless combustion by not being dependent upon natural draft, with its uncertainties due to atmospheric conditions, and by being able to get a uniform pressure and an absolute control of the volume and pressure of the air.

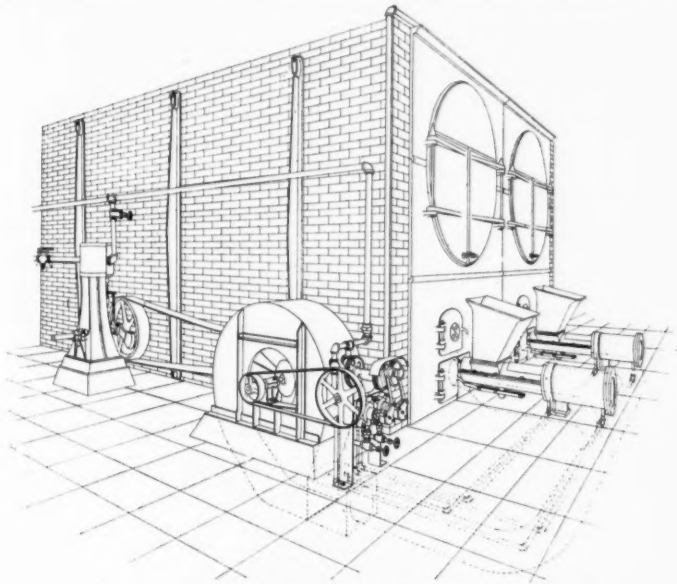


FIG. 10. COLE AUTOMATIC ATTACHMENT TO JONES STOKER.

The reason stoker operation by the underfeed principle is smokeless is that the fuel bed consists of three strata. The green coal forms the first or lower layer; the coal immediately above, in process of coking, forms the second layer, and the third is the zone of complete combustion, composed of incandescent coke. Necessarily, then, the distilled gases from the green coal must pass through the incandescent fuel, and in so doing they meet the air for combustion just above the first layer, thereby forming a thorough mixture which is at once consumed in passing through the fires above. In other words, the gases which are ordinarily so ready to form smoke are mixed with just the right amount of preheated air at the ignition temperature.

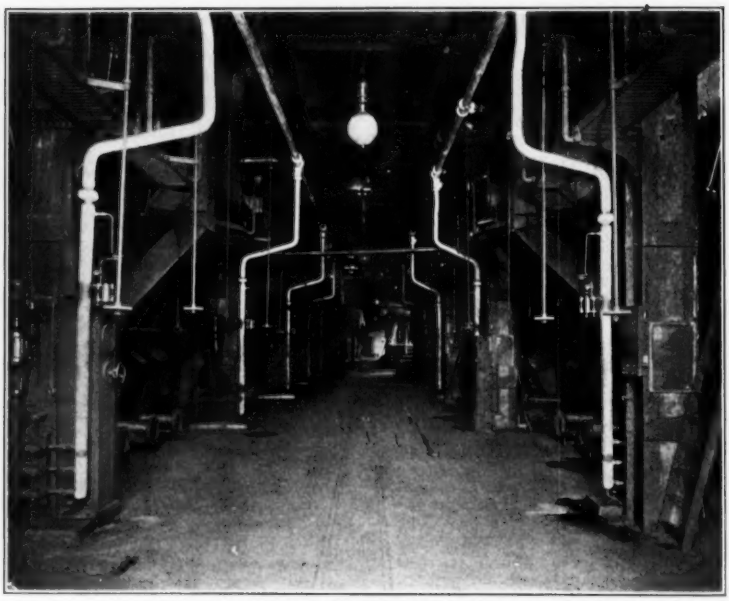


FIG. 11. JONES STOKERS IN BOILER ROOM OF BOCA STATION, CATE, BUENOS AIRES.
Under-Feed Stoker Company of America.

The manufacturers of this stoker have collected figures from numerous tests, conducted for the purpose of determining the cost of operation, and they state that the cost of operating the stoker and forced draft mechanism ranges from ½ to 1½ per cent of the saving effected.

The main advantages of this stoker are:—

1.—Simplicity of construction, which means quick installation.

2.—Adaptability to practically all commercial types of boilers.

3.—No moving parts in the fire, and consequently low maintenance cost of parts in furnace.

4.—Absence of coking arch or special fire-brick combustion and coking devices.

5.—Ability to respond quickly to capacity demand from a banked condition, on account of thick fuel bed maintained.

6.—Accessibility under all conditions of operation.

7.—Absolute control of admission of fuel and air to the furnace at a fixed ratio, which means ability to govern capacity at will, and to insure economic and smokeless combustion.

8.—If operated properly, reduction of percentage of combustible

matter in the refuse to a minimum, as the fuel cannot escape until it is consumed.

Some of the disadvantages of this stoker are:—

1.—The necessity of installing and maintaining forced-draft mechanism (which is true for any underfeed stoker) and of duplicating the auxiliary apparatus to insure against breakdowns.

2.—Necessity of installing and maintaining steam and exhaust piping for the rams, with the consequent liability of leakage and breakage.

3.—The liability of the tuyere blocks to crack and burn out, though these are practically the only parts in the stoker that can do so.

4.—The necessity of using a certain amount of floor space in front of the boiler.

5.—The necessity of operating the rams against a head of fuel.

6.—During the cleaning of the fires the draft has to be shut off and the process of combustion stopped until the fires are cleaned and the boiler is swung into line again. Several improvements in this respect, however, are now being considered.

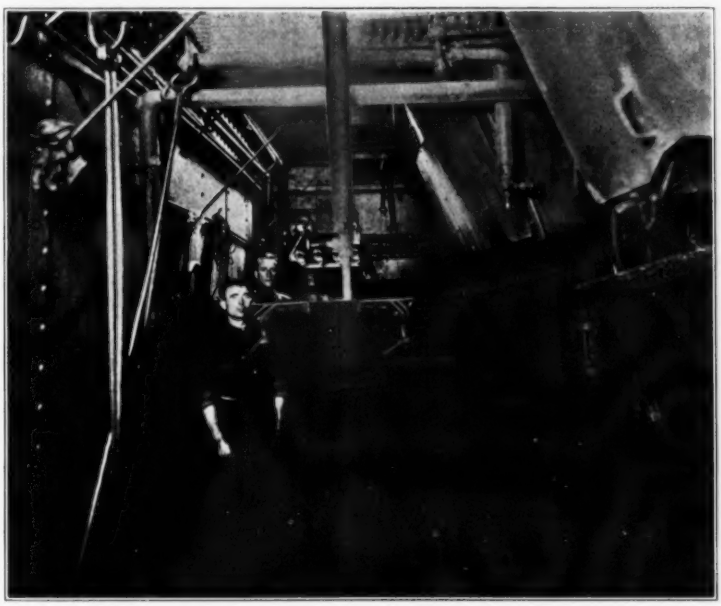
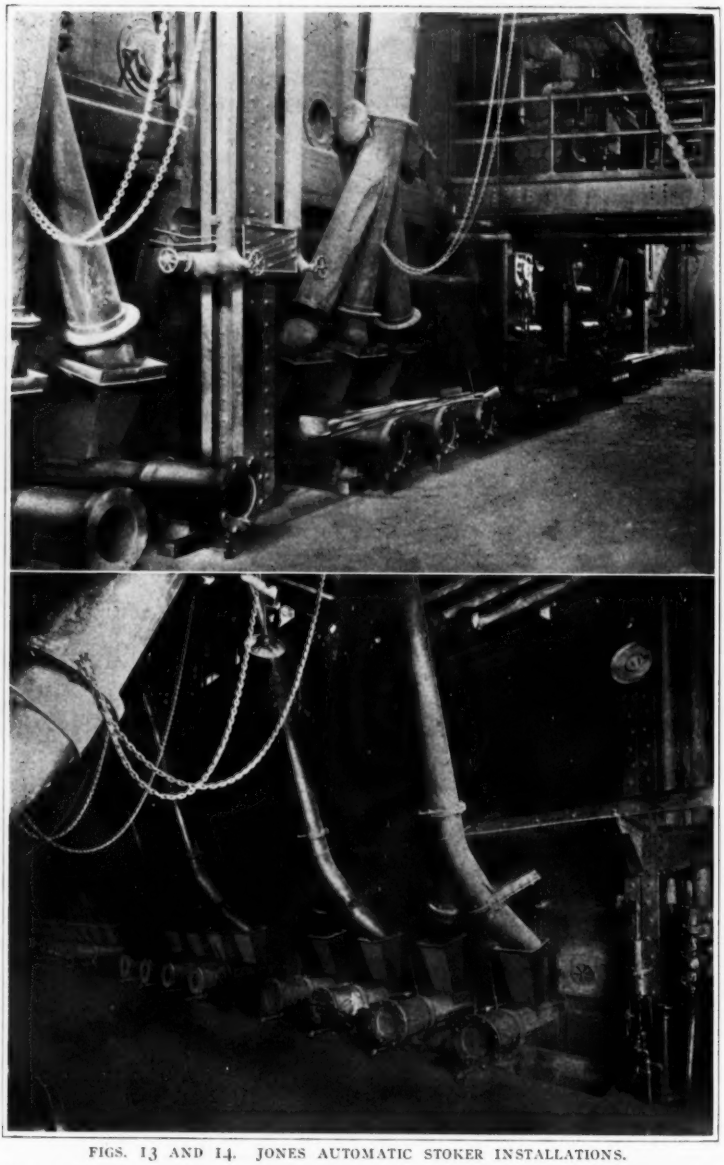


FIG. 12. JONES STOKERS, FIRE HOLD OF DREDGE F. J. SIMMONS, CHICAGO.



FIGS. 13 AND 14. JONES AUTOMATIC STOKER INSTALLATIONS.

Above, plant of Central Heating Co., Detroit; north side of boiler room. Below, Commerce St. Station, Milwaukee Electric Railway & Light Co. The Under-Feed Stoker Co. of America.

The very latest type of underfeed stoker is the Taylor Gravity Underfeed Stoker, manufactured by the American Ship Windlass Co., of Providence, R. I.

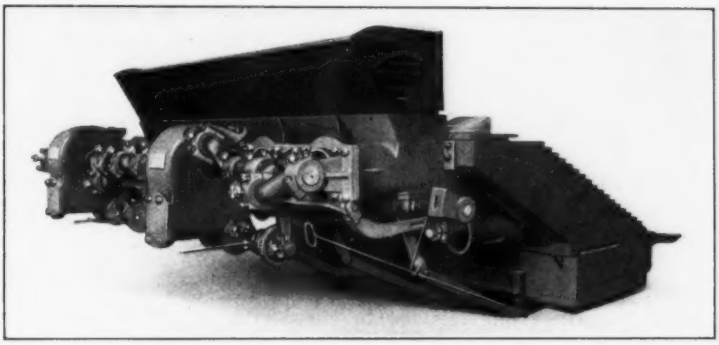


FIG. 15. GENERAL PERSPECTIVE VIEW OF THE TAYLOR STOKER.

As may be seen from the cuts (Figures 16 and 17), this stoker is a combination of the inclined and gravity under-feed principles, and consists of an inclined bed for fuel, made up of perforated tuyeres, which are hollow rectangular (cast-iron) plates, laid up in steps. The lower tuyeres rest on a rectangular wind box which is connected to the forced-draft ducts. Between each two rows of tuyeres are two cylindrical trunk pistons or rams, the upper ram taking the coal from the hopper, and the lower one feeding only the coal and partially consumed combustible matter and coke delivered from the upper ram. These two rams move in unison, the upper one being operated by a crank shaft in front of the boiler, which derives its motion from a double-reduction screw and worm-gear enclosed in an oil-tight gear box in front of the boiler, bolted to the ram casings. The speed worm is driven by the prime mover, which usually is the blower engine. There is a clutch between the speed worm and the sprocket wheel. In order to obviate any trouble due to an obstruction being introduced into the hopper, shear pins are inserted between the sprocket and the clutch. These pins are large enough to transmit the power necessary to operate the stoker, but will shear when more power is exerted. The lower ram is connected to the connecting rod of the upper ram in such a way that the travel is ordinarily 2 to 3 inches, depending, of course, upon the varying ash conditions. The travel of the upper ram is fixed at about 12 inches. At the base of the wind box is hinged the sectional dumping plate which is operated by levers and locks from the boiler front. These plates are unper-

forated, since combustion is supposed to have been completed by the time it is necessary to clean fires or dump the refuse.

The operation of the stoker is as follows:

Coal is fed into the hoppers, either by hand or by a gravity system, from whence it is carried into the combustion chamber by the several rams and is pushed forward and downward by the upper rams. Here the distilled gases meet highly heated air which is projected horizontally into the furnace. The result is that the gases are intimately mixed with just the right amount of air at the proper temperature, giving the conditions for perfect, smokeless combustion. The combined action of the rams is to break up the fuel regularly and continually, rendering it unnecessary to slice or level the fire. The fireman merely has to attend to the dumping of the fires at the end of the stoker at regular intervals. These intervals depend, of course, upon the quality of the fuel and the rate of combustion.

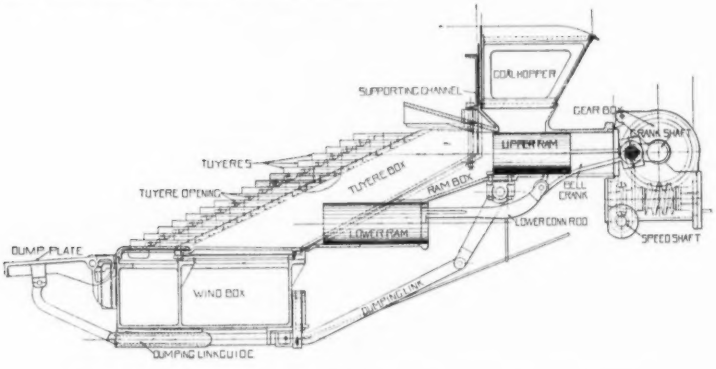


FIG. 16. SIDE ELEVATION OF TAYLOR STOKER, SHOWING CONSTRUCTION.

The speed of the stoker or rate of driving is controlled by means of a chronometer valve in the blower-engine steam pipe, the valve being connected to the damper regulator. The damper in the main flue having been disconnected from the damper regulator, is locked wide open, and the regulator is connected to the chronometer valve; therefore, as the steam rises or falls, the chronometer valve controls the speed of the blower engine accordingly, and since the stoker is driven by the blower engine, the speed of the stoker is regulated simultaneously with that of the blower engine. Hence, the relation of the coal and air used is the same at all rates of combustion. Ordinarily, the stoker crank shaft makes about 30 revolutions per hour.

This stoker uses no combustion or coking arch for smoke prevention, and yet it is practically smokeless for almost any range of capacity. This is due to the fact that the distilled gases and volatile hydrocarbons must pass through a zone of incandescent fuel where they are entirely consumed, being previously mixed with the proper proportion of preheated air.

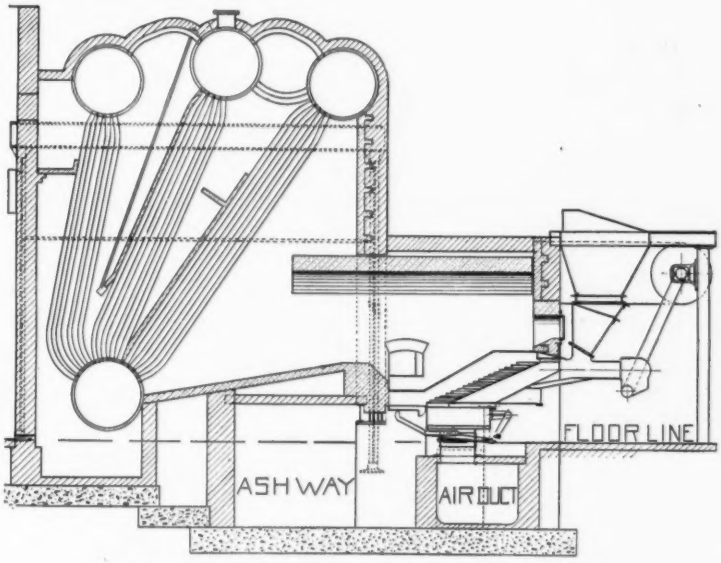


FIG. 17. TAYLOR STOKER APPLIED TO STERLING BOILER.

The principal advantages of this stoker are:—

1.—High efficiency over entire range of operation.

2.—Smokeless combustion over wide load range.

3.—Maximum possible capacity that can be obtained from the boiler; 70 pounds of coal per square foot of grate surface is not beyond the limit of economic operation.

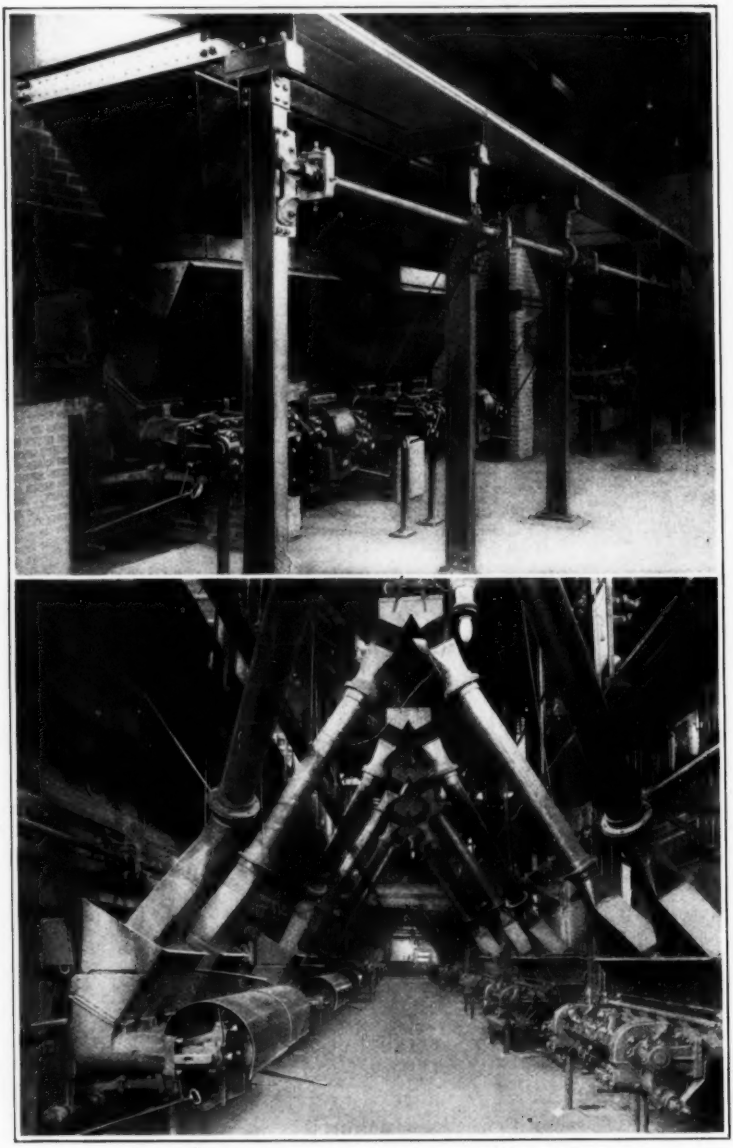
4.—Entire absence of coking arch or special fire-brick combustion and coking devices.

5.—Ability to respond quickly to capacity demand from a banked condition, on account of the thick fuel bed maintained.

6.—No moving parts subjected to the heat of the fire, the boiler fronts never being more than comfortably warm.

7.—Low operating and maintenance cost on account of simplicity of construction and slow speed of moving parts.

8.—Saving in power for operating the stoker. The boiler men-



FIGS. 18 AND 19. INSTALLATIONS OF TAYLOR STOKERS.
Above, the Phillipdale Paper Mill; 250 horse-power water-tube boilers, with auxiliary storage hoppers. Below, the Oxford Paper Co. power plant, comprising 7,875 horse-power.

tioned in the test required approximately 2½-5 horse power to drive it over the entire load range.

9.—Reduction to a minimum of the per cent of combustible matter in the refuse.

Some of the disadvantages of this stoker are:—

1.—Initial investment on installation. To partially balance this, the saving in labor, operating and maintenance cost, especially the cost of maintaining a fire brick arch, should be credited.

2.—Necessity of using forced draft with attendant investment in this apparatus, maintenance, etc., and of duplication of auxiliaries to insure against breakdowns.

3.—Liability of dumping plates to burn out and crack, though this difficulty is being removed by the sectional dump plate devised as a new feature of this stoker.

4.—Burning out of tuyere plates and ram covers. This, however, is practically all there is in this stoker to burn out and, owing to the method of construction, the cost of replacing and maintaining them is reduced to a minimum.

5.—The possibility of breakage in the driving and moving parts, though this difficulty is rather remote owing to low speed of operation and to the device of using shear pins to transmit only the necessary power.

The fourth type of automatic stoker is the chain grate, the example chosen being the Green chain grate, manufactured by the Green Engineering Company, of Chicago, Ill. This stoker is essentially an endless chain of a width equal to the fire-box and extending from the front of the boiler to the bridge wall, the individual links of the chain being the grates. Special forms of link are required for individual cases. Coal is fed into the hopper at the front of the boiler directly over the grate. The grate is operated by an eccentric keyed to the main driving shaft, the eccentric in turn transmitting its motion to a ratchet and ratchet wheel, connected by a gear train to the main driving gear on the chain-grate shaft. The speed of the chain grate is controlled by adjusting the throw of the ratchet arm. This chain grate is mounted on a portable frame and track in the ash pit, which allows for the expansion and also permits of adjusting the clearance between the end of the chain grate and the bridge wall, depending upon the rate of driving and the character of the fuel. The stoker is provided with a vertically movable gate at the rear of the coal hopper (see Figure 20), which serves to scrape off the layer of fuel to a thickness determined by the height of the grate. This can be readily adjusted from the outside of the stoker frame

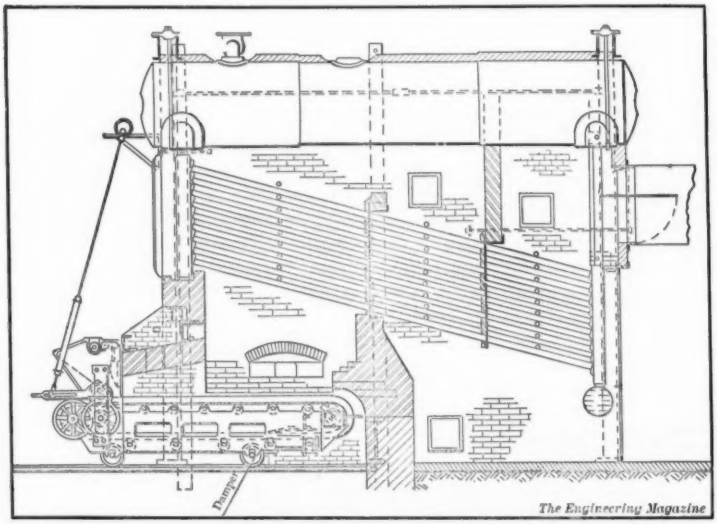


FIG. 20. GREEN TRAVELING LINK GRATE UNDER A BABCOCK & WILCOX BOILER.

by means of a worm and sector attached to the transverse grate shaft. The gate, being suspended from lever arms on the gate shaft by adjustable chains, can be set so as to be parallel to the grate surface, thus obtaining uniformity of fuel depth across the grate. The rear of this gate is lined with fire-brick tiles of such special design that any of them can be replaced while the stoker is in operation.

The operation is as follows: The coal is fed, either by hand or by coal downtakes, into the hopper, from which it falls directly onto the moving chain grate. The gate then levels the fire, and as the fuel travels under the coking arch it ignites immediately. The heat from the arch and from the back of the grate is sufficient to ignite the volatile hydrocarbons, which are mixed with air as in the ordinary furnace. The fuel then burns continuously the whole length of the grate as it moves forward, bringing in fresh fuel at the front and dumping the refuse automatically at the back as fresh grate surface is presented. The smokeless feature of this stoker is well worthy of comment, for it was this stoker, set under a Heine boiler, with a Dutch Oven and tile roof, that prompted Prof. L. P. Breckenridge to remark—"that in this setting, it has been impossible to make smoke."

This stoker is ordinarily set in a Dutch oven, the roof of which forms an ignition arch which is placed from 1 to 2 feet above the grate surface. As the volatile matter is distilled from the incoming

fuel, it impinges upon the underside of this arch during its combustion and gives up heat thereto. This arch then becomes white hot, and its reverberatory action serves to ignite fresh fuel. The longer this arch is made, the longer is the travel of the hydrocarbons in contact with it, and thus it aids complete combustion of the volatile matter by prolonging the time in which the hydrocarbons are contained in the high temperature chamber. The special advantages of this stoker are:—

1.—Smokeless combustion with coals running above 30 per cent in volatile matter over ranges of from 50-140 per cent of rating, and in some special cases 200 per cent of rating.

2.—On account of the regularity in the rate of feeding coal into the fire-box, the volatile matter is distilled off evenly, and owing to the automatic discharge of the ash from the furnace and the automatic self-cleaning of the air spaces in the grate surface, the necessity of dumping ashes by hand with consequent inrush of cold air is entirely avoided, and continuous, uniform high furnace temperature is maintained with the attendant result of economic combustion.

3.—Ability to burn, efficiently, almost any small-size bituminous coal on the market.

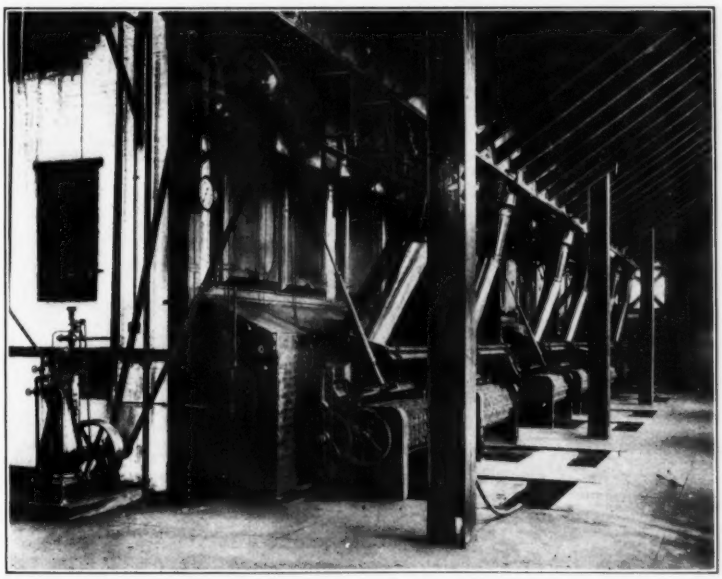


FIG. 21. GREEN CHAIN-GRATE STOKERS, SHOPS OF THE CHICAGO & NORTHWESTERN RAILROAD.

4.—Ability to operate on natural draft.

5.—Fairly high economical operation over comparatively wide range.

6.—Accessibility to any of the parts of the stoker or furnace on account of its removability from the furnace chamber.

Some of the disadvantages are:—

1.—Necessity of installing a Dutch oven for vertically baffled boilers, but for such settings the combined economy of the boiler and furnace increases as the stokers are forced.

2.—Necessity of maintaining an ignition or coking arch, for horizontally baffled boilers, the expense of which, however, is no greater than in any other stoker.

3.—Liability of having to shut down the stoker and to pull the boiler off the line if anything happens to the grate bars or grate-bar tie rods, which is more serious than can be repaired while the stoker is in operation. This may happen if the fuel runs high in iron oxide and forms a pasty clinker. Ordinarily the stoker chains can be repaired without stopping the stokers.

4.—The stoker has moving parts such as guide wheels, track, rear sprocket wheel, bearings, etc., in the fire-box or ash pit, where they may be either subjected to the direct heat of the fire or its radiated heat. Most of these parts, however, are carefully protected.

5.—If the height of the water back is not suited to the kind of coal fired (which is a nice question of design) and unless the stoker is carefully operated, the percentage of combustible in the refuse is liable to be high, on account of the clearance at the back of the stoker between the bridge wall and the grate.

6.—Maintenance of the arch and moving parts may make the maintenance high in cost, but if carefully operated and intelligently handled, this cost will not be higher than for any other stoker of similar type.

7.—Unless carefully designed, there is liability of air leakage between grate and side walls and between end of grate and bridge walls. The radiated heat from side walls causes the edge of the fire to burn more rapidly than the center, tending to increase this air leakage toward the rear of the furnace.

8.—Difficulty of adjusting the speed of the grate to the capacity demand and the draft so as to burn out the coal efficiently before it is dumped at the bridge wall.

9.—Sifting of fine coal through the grates.

METHODS OF THE SANTA FE. EFFICIENCY IN THE MANUFACTURE OF TRANSPORTATION.

By Charles Buxton Going.

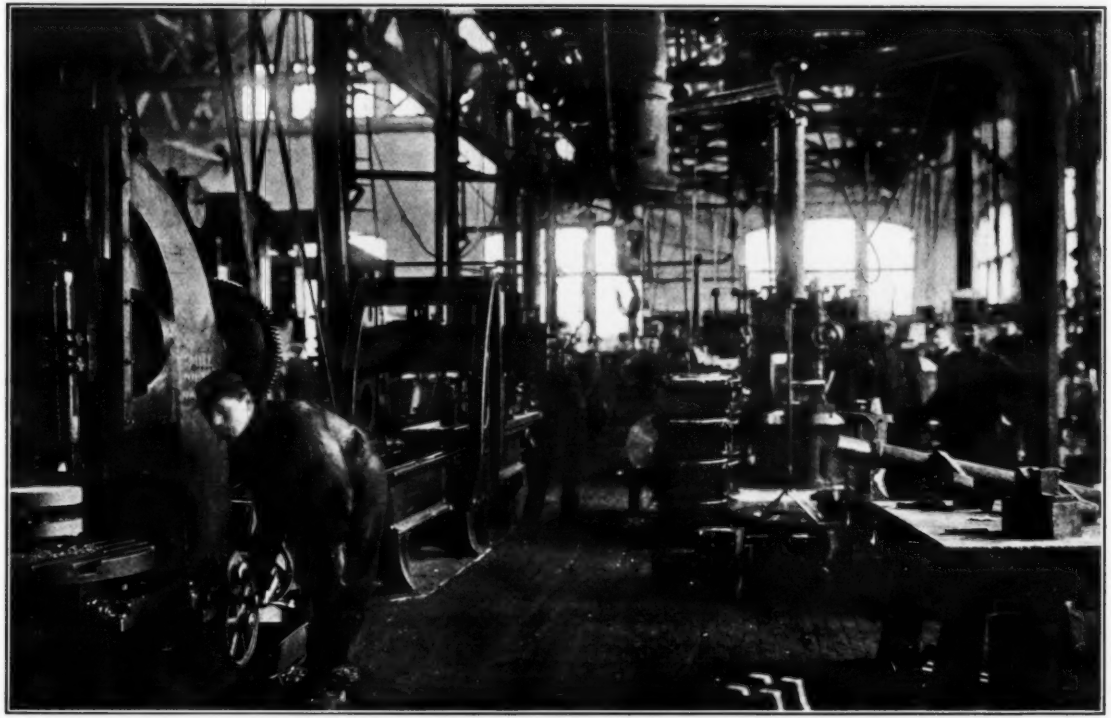
V. THE APPRENTICE SYSTEM, AND RELATIONS WITH EMPLOYEES.

The series of which this article is the fifth and last began in our March issue. Preceding parts have summarized the chief problems of the Santa Fe and their solution, the stores-keeping system in its relations to the mechanical department and the manufacturing organization in the shop, the general outline of the "efficiency methods," and the methods and projects for the extension of the bonus plans outside of the familiar field of shop labor, in new and original directions. This concluding paper details the apprenticeship system and other characteristic relations with employees.—THE EDITORS.

IN effect, the efficiency system for the payment of labor, as practiced on the Santa Fe, is a means of establishing individual contact with each employee. The bonus is a direct participation in the profits secured by improved methods—voluntarily extended, voluntarily received—an automatic and indefeasible means by which every man, be he foreman, bench-hand, or wiper in the roundhouse, shares in savings as surely as the director, the bondholder or the stockholder; more surely, indeed, for his savings are not subject to impairment by reason of diminished net earnings. The pre-eminent characteristic is the direct address to the individual, which is not dependent upon the favor or whim of his immediate superior and which can not be altered or diverted by prejudice or partiality.

The bonus system alone, however, serves to maintain this individual relation with the man only as a producing unit. It is limited in time and in extent to the working hours of the day and to the working period of the employee's life. The whole policy of the Santa Fe, in its relations with its men, is far broader than this. It begins with the formative period preceding full employment as mechanic in the shops; it extends to many matters concerning physical and mental well-being during employment; and it follows retirement after the full term of work is completed, assuring the faithful and meritorious ex-employee against want when he is no longer able to render service to the road.

The introduction to this more than usually individual association between employer and employee begins with indenture to apprenticeship. This is now the mode of entry into the service for about one-half the company's shop men, and the system is rapidly expanding



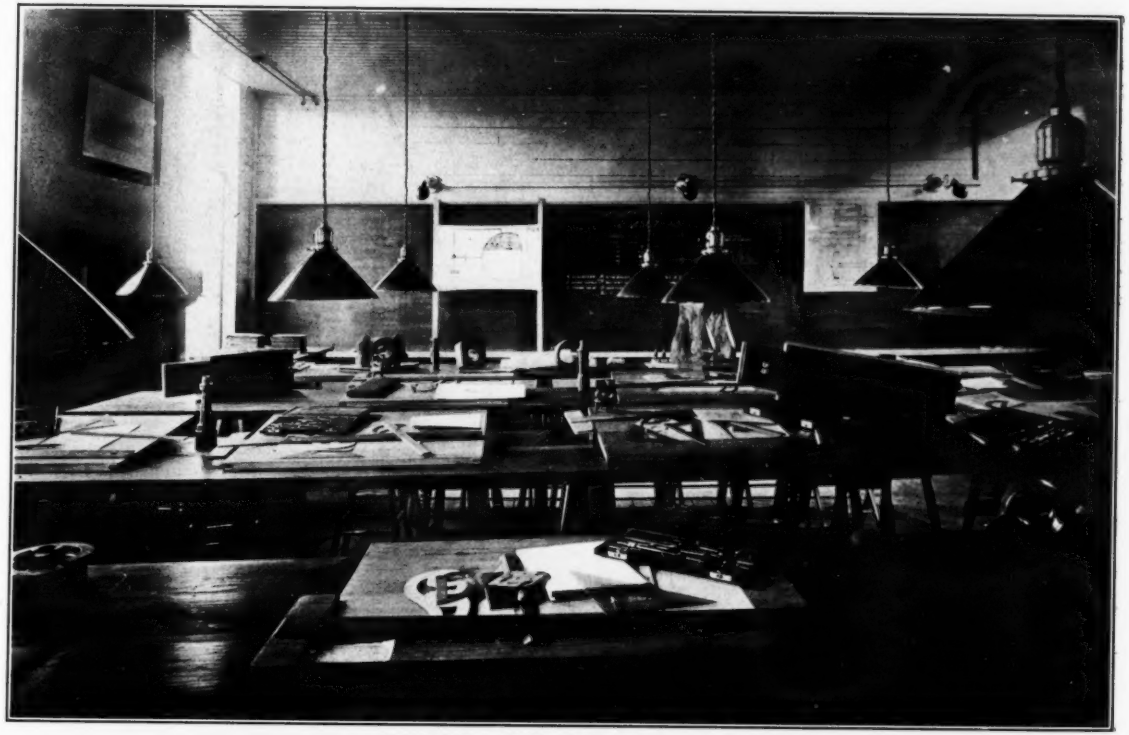
APPRENTICES AT WORK IN THE SAN BERNARDINO SHOPS.

to the point where it will recruit the entire shop forces with first-class, skilled mechanics, trained in the "Santa Fe way." Apprenticeship, *per se,* is of course not a new institution, even in railway work. Indeed, in developing its present methods to replace the old haphazard apprenticeship which had existed for years, the present supervisor of apprentices of the Santa Fe made careful study of the improved methods already in force on the New York Central and Pennsylvania railroads, in the shops of the Westinghouse, General Electric, and Baldwin Locomotive works, and other leading cases. The result, however, has been the creation of distinctive and characteristic institutions suited to the conditions and purposes of the road, and distinguished by systematic instruction carried on continuously in two phases—on the shop floor, and in shop schools, under regular instructors during the whole four years of apprenticeship, the boys being paid according to a graduated wage scale from the very beginning of this term.

Apprentices entering the service must be between 16 and 22 years of age,* sound, mentally and physically, (as proved by medical examination by the company's physicians) and possessed of a good common-school education equivalent to that acquired in the sixth grade in the Kansas public schools. Preference is given to sons of Santa Fe employees. Recommendation of a candidate by an instructor of apprentices is conclusive as to mental and moral fitness, and applicants so presented need pass only the physical tests as to age, height, weight, and freedom from organic trouble or hereditary or contagious disease. If the boy comes without recommendation, he is asked to fill out a regular form and is informally quizzed or talked with to gauge his mental calibre. Cigarette smokers are not employed, and any apprentice acquiring the habit is dismissed.

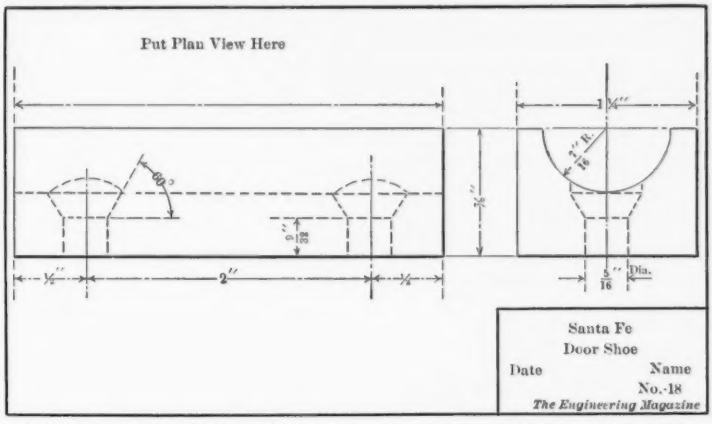
Apprentices work 10 hours per day on each working day except Saturday, 300 full shop days worked during regular shop hours constituting one year on the four-years indenture. Credit not exceeding two years may be given for prior work of the same kind elsewhere. In case of transfer to another shop of the road, full credit for time worked in the first shop is allowed. During June, July and August apprentices work but 5 hours on Saturday (at the discretion of the shop superintendent or master mechanic) and are credited with 5 hours on the payroll and 10 hours on the agreement. On Saturdays of the other nine months of the year they work 9 hours and are credited with 10 hours on both payroll and agreement. As night work interferes with attendance at the apprentice schools, and de-

* In California the upper age limit is 18 years.



APPRENTICE SCHOOL ROOM, LA JUNTA, COL.

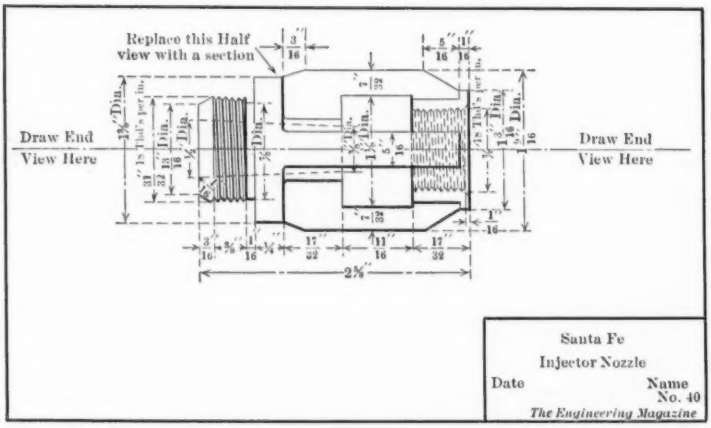
prives the apprentice of the benefit of the regular shop instruction, assignment of apprentices to regular night work is forbidden, and their employment in special emergency night work is limited to a maximum of six consecutive nights. The most interesting feature of the system is the careful provision made for training the lads thoroughly and methodically under regularly assigned instructors, both in the shops where they are learning the actual practice of their trade, and in organized apprentice schools where they study those branches necessary to the thorough mastery of the subject which should characterize a good journeyman.



SAMPLE DRAWING EXERCISE, SANTA FE INSTRUCTION COURSE FOR APPRENTICES.

The school-room courses, which are obligatory, are established at all the larger shops (eleven in number) and require attendance of the apprentices 2 hours a day 2 days in the week. The time spent in the class-room is counted as part of the working day and is paid for by the company just as if the boy were at work. In the largest shops classes are held morning and afternoon, the apprentice force being divided into sections; in smaller shops the class-room hours are adapted to local conditions.

The scheme of instruction is thoroughly practical. It includes simple mechanical and free-hand drawing and descriptive geometry, (as, for example, the developing of surfaces for boiler and tin-shop work); practical shop arithmetic (the problems generally involving use of the ordinary shop scale and extending to decimals and ratio and proportion) and simple mechanics, including the block and pulley, lever, etc. Everything is specialized to the prospective employment in the mechanical trades, and is designed to induce satisfaction with



A MORE ADVANCED DRAWING EXERCISE, SANTA FE INSTRUCTION COURSE FOR APPRENTICES.

trades employment. The course for the first two years is uniform for all apprentices, but after that it is diversified so that apprentices in the several callings may be specially fitted, each to his own trade. There are no formal examinations, but the last sixty days of a boy's time, and certain intermediate periods when he is being transferred from one machine to another, are given to quizzes designed to show how thoroughly he has assimilated the instruction given him. The questions put are all practical and directly pertinent to ordinary work, and are wholly free from mere catches and tricks. Apprentices completing their course satisfactorily receive certificates signed by the regular officials of the company. The recognized standing of the training received under the Santa Fe system makes these certificates valuable as recommendations anywhere. The term of apprenticeship is not prolonged even if the boy makes a poor appearance at this examination, but his rate of pay after he is out of his time is governed by his ability and knowledge as thus determined. This variable wage scale, instead of a fixed one at the end of the apprenticeship period, furnishes an automatic discouragement to the careless and an incentive to the faithful apprentice.

The scheme contemplates, also, the exercise of modified military discipline and control over the boys, not so much during working hours as on the streets or in public places. This, however, is exerted morally rather than formally. If an apprentice is absent three days, his instructor calls to make inquiry, using the company's time for the visit if it is too far to make in the evening.

Some of these measures and other features of the system are at present tentative, the company's methods being so largely pioneer that they must be worked out without the guide of precedent or of experiment elsewhere. Informal meetings with the instructors are appointed weekly by the supervisor of apprentices for general discussion of measures and results.

Santa Fe

Certificate of Apprenticeship

The Atchison, Topeka & Santa Fe Railway System

This is to Certify that _____

has regularly and faithfully served _____ years in the shops of this Company at _____ learning the trade of _____. His services and conduct have been satisfactory and he has become a competent and skillful mechanic.

Executed this _____ day of _____ 19__

In Witness Thereof we have set our signatures.

SUPERVISOR OF APPRENTICES

SUPERINTENDENT MOTIVE POWER

THE CERTIFICATE OF APPRENTICESHIP PRESENTED ON COMPLETION OF THE COURSE AT THE SANTA FE SCHOOLS AND SHOPS.

In general, the policy is to place an instructor over a minimum class of 16 boys. In special cases, however, an instructor is installed for only 12 apprentices, the instructor in such cases doing certain technical work for the master mechanic to fill out his partially employed time. The small shop having less than 12 apprentices is a problem of some difficulty. Various efforts are being made to provide for these cases, either by bringing the boys periodically to a

1. An order of bolts weighs as follows: 10 bolts 45 lbs. each, 6 bolts 8 lbs. each, 15 bolts 2 lbs. each and 3 bolts 2 lbs. each. What is the total weight of the order?

2. What would be the cost of the above order at 2 cents a pound?

3. A freight train takes 9 hours to go a distance of 153 miles. What is the average speed per hour?

4. The distance around the driving wheel of an engine is 22 feet. How many feet will it travel in making 6,748,821 turns? There are 5,280 feet in one mile—how many times does it turn in one mile?

5. A load of castings is weighed in 9 lots as follows: 175, 457, 842, 961, 244, 857, 806, 973, and 200 pounds. What is the weight of the load?

6. Five steam engines consume respectively the following amounts of coal per hour: 365, 783, 634, 570, and 630 lbs. What is the total amount of coal consumed each hour by all the five engines?

7. Conditions as above, how much coal would be consumed by the five engines running night and day for six days? What would be the cost at $1.75 per ton?

8. How many pieces 3 inches long can be cut from a brass rod 63 inches long if no allowance is made for waste in cutting?

10. If 7 castings weigh as follows: 620, 789, 630, 87, 7, 189, and 223 pounds, what is total weight?

11. If 83 pounds of the above is used for a certain job, how many pounds will remain?

12. Which number is near to 633, 212 or 1,100? How much?

13. If the consumption of water one month was 15,863,743 gallons, and for the following month 12,678,963 gallons, what was the decrease?

14. From 3,400,678 subtract 1,823,765.

15. If the cost of constructing 362 miles of railway is $4,561,200, what is the cost per mile?

16. Multiply 346,783 by 27,805.

17. Divide 5,914,048 by 2,456.

18. What is the average speed of a train per hour which takes 8 hours to go a distance of 144 miles?

102. Find the overall dimensions on a drawing made up of the following detail dimensions: 5.27 inches, .63 inch, 3.14 inches, 2.375 inches, and 4.2 inches.

103. Find the total weight of four pieces of cold rolled steel shafting, 2 3-10 inches in diameter, weighing as follows: 67.62 pounds, 96.18 pounds, 114.38 pounds, and 87.12 pounds.

104. If a cap screw is 1.78 inches long under head, and the thread stops .9 inch from the head, how much is threaded?

105. The following numbers represent in thousands of feet the amount of lumber issued on 8 requisitions: 6,805, 24,245, 16,308, 12.28, 18.2, 6,395, 24, and 18,907. What was the total amount of lumber issued on these requisitions?

106. The diameter at the bottom of the threads of a 1-inch thread is .837 inches. What is the depth of the threads?

107. What would be the inside diameter of a tire that was turned for a 78-inch wheel center, if .081 inch was allowed for shrinkage?

108. The inside diameter of a cylinder is 22.625 inches before and 22.875 after boring. How much larger is the cylinder after boring?

200. In bushing a cylinder 30.656 inches in diameter to fit a piston 28.625 inches in diameter. What would be the thickness of the bushing in inches if the bushing is made .005 larger in diameter than the piston?

201. In pressing the above bushing into the cylinder it was found to contract .02 of an inch inside diameter. To allow for the shrinkage, what was the outside diameter before pressing into the cylinder?

202. An apprentice works the following hours on different jobs: 7.5, 16.3, 17.9, 20.7, 45.3, 20.6, 50.3, 6.0, 14.5, and 30.6. What is his total time?

203. The time allowed on the above was 269.1 hours. How many hours did he beat the schedule?

central point, by installing a traveling instructor to cover, say, three shops for two days a week each, or by moving apprentices permanently from these local points to larger central shops where classes are regularly established. This last course, however, is not at all approved by the master mechanics at the minor points—an evidence of the favor with which the apprenticeship system is regarded by shop officials on the system.

SANTA FE SYSTEM APPRENTICE SCHOOL. SOME MORE TYPICAL PROBLEMS.

281. To find what per cent one number is of another, divide the first number by the second, and reduce the resulting decimal (or mixed decimal) to per cent. (The divisor is usually the first number following the word "of".)

A machinist was paid $17.67 in addition to his regular wages of $88.40. What per cent. of his regular wages was given him as bonus? Solution: 17.68 ÷ 88.40 = .20 = 20 per cent. Ans.

282. An apprentice's standard time for May was 188.7 hours, his actual time 225.2 hours. What was his per cent. of "efficiency"? That is, what per cent. of his actual time was the standard time? Solution: 188.7 ÷ 225.2 = .838- = 83.8 per cent. Ans.

283. What is the "efficiency" of an apprentice whose standard time was 177 hours and whose actual time was 238 hours? Note.—Divide the standard time by the actual time.

284. In May a second year apprentice at Cleburne accomplished in 249.7 hours an amount of work for which 283.8 hours standard time was allowed. What was his per cent. of efficiency?

285. For this efficiency the above mentioned apprentice received 83.7 per cent. of his wages as bonus. If his ordinary wages amounted to $39.95, how much bonus did he receive?

286. A first year apprentice whose efficiency was 110 per cent., received $21.34 bonus. What per cent. of his ordinary wages of $28.45 was paid him as bonus?

287. If the total weight of a steel freight car when loaded is 139,800 pounds, and the weight of the empty car is 39,800 pounds, what per cent. of the entire weight is the weight of the empty car? What per cent. of the total weight is the weight of the freight carried?

288. An axle originally weighs 1.038 pounds, and loses 6½ per cent. when turned. What is the final weight?

289. The braking power (pressure in pounds applied on wheels through brake shoes) of freight cars is 70 per cent. of the weight of the cars. What is the braking power of a box car weighing 36,700 pounds?

290. The braking power of a passenger car is 90 per cent. of the weight of the car. What is the weight of a baggage car having a braking power of 52,200 pounds?

291. Find the braking power in pounds on a sleeping car weighing 118,400 pounds, if the braking power is 89 per cent. of the weight of the car.

292. If 70 of the 840 staybolts on a locomotive are found to be broken, what per cent. are broken?

Each apprentice is provided with all necessary class-room materials free, and an individual set of drawing instruments is assigned to him at once on entry. If any of these are broken in ordinary fair use they are repaired or replaced at the company's expense, but if by carelessness or willfulness, at the boy's expense. At the end of his term they become his property. Necessary tools for the first six months are provided, the apprentice being required to turn them in to the shop instructor at the close of each day. At the end of the

TOOLS SOLD WOOD-WORKING APPRENTICES.

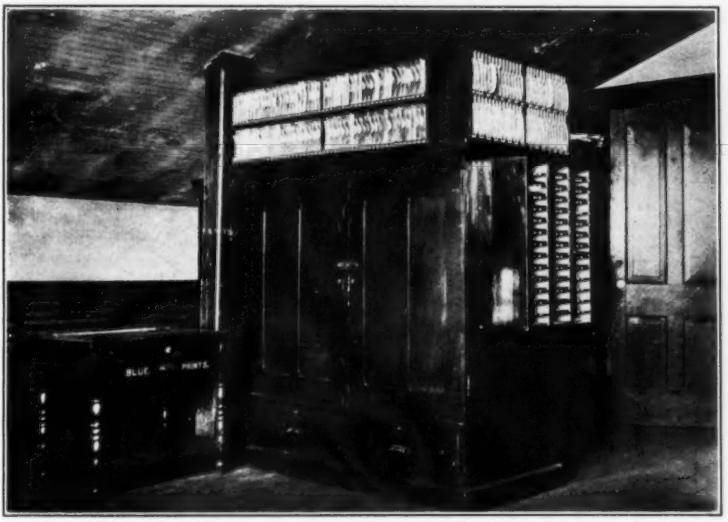
1 No. 11½, claw hammer, V & B
1 No. 122, 6-inch ratchet brace
1 Set Cleveland wood bits, ⅛ to ⅜ in 32ds
1 Set Irwin's auger bits
1 Set Witherby No. 15 bevel back chisels
1 Set No. 320, socket gouges
1 No. 30, Yankee screw driver
1 No. 12, screw driver bit ¼ inch
1 No. 12, screw driver bit ⅜ inch
1 Clark's expansive bit ⅞ inch to 3 inches
1 No. 77, Mortise gauge
2 No. 64½, Stanley gauges, each 20 cents
1 No. 71½, Router
1 C. C. hand saw 24-inch 10 pt
1 Disston 12-inch back saw No. 4
1 3¼ x 6, Stanley cabinet scraper
1 Set of Victor nail sets
1 Lily white oil stone 2 x 1 x 7
1 No. 67, Universal spoke shave
1 No. 8, jointer plane
1 No. 4, smoothing plane
1 No. 5, jack plane
1 No. 9½, block plane
1 No. 94, Bailey rabbit plane
1 No. 85D, extension dividers, 9-inch
1 Steel square 16 in. x 24 in.
1 No. 20, 9-inch try square
1 No. 12, 4-inch try square
1 No. 18, bevel square

TOOLS SOLD MACHINIST APPRENTICES.

1 No. 79, 4-inch outside spring caliper, solid nut
1 No. 79, 6-inch outside spring caliper, solid nut
1 No. 26, 10-inch outside caliper
1 No. 73, 4-inch inside spring caliper, solid nut
1 No. 73, 6-inch inside spring caliper
1 No. 27, 10-inch inside caliper
1 No. 80, 4-inch spring outside thread caliper
1 No. 41, 6-inch Hermaphrodite caliper
1 No. 420, 6-inch scale, No. 4 graduation with hook
1 No. 11, combination square, 12-inch scale blade
1 No. 57B, Universal surface gauge, 12-inch spindle
1 No. 4, screw pitch gauge
1 No. 390, center gauge
1 No. 77, spring nut, 6-inch dividers
1 No. 59, Starrett's trammel heads

six-months' period, the apprentice, having proved his adaptability to his trade, is required to buy the necessary hand tools. The character and extent of this equipment is indicated by the list here reproduced. This outfit is supplied by the company at wholesale prices, the full set arranged in a tool box, marked with the apprentice's name and provided with lock and key. The kit is inspected by the instructor

weekly, in order to see if it is in good condition, and instruction is given the boy how to keep the tools in condition. He is not allowed to lend to any one nor to borrow from anyone except on explicit instructions, nor to remove any of the tools from the shop without written authority from the instructor. The tools are of the best quality, guaranteed by the seller, and if any defect appears the tool is replaced at once upon request of the supervisor of apprentices, without question or debate. Payment is made by the apprentice at the rate of $1.50 to $2 a month, no charge being added for interest or handling, and the installment payments being remitted by special intervention of the supervisor of apprentices if the shops are shut down entirely for any length of time and the apprentice's wages are thus temporarily cut off.



FILING CABINET FOR DRAWING BOARDS, BLUE PRINTS AND PROBLEM SHEETS, ALBUQUERQUE APPRENTICE SCHOOL.

The boys are taught to cut their own drawing papers on the small table at the left.

Shop training for the apprentices presents more and larger problems than the class-room work. One reason for this is the number of trades represented—machinists, brass finishers, boiler makers, blacksmiths, cabinet makers and coach carpenters, tinners and coppersmiths, pattern makers, painters, miscellaneous and special. Topeka alone includes the entire list, but several shops have apprentices in a half-dozen trades to be provided with specialized instruction. Another cause of possible perplexity in the shop arrangements is the

NUMBER OF APPRENTICES IN EACH TRADE AT EACH SANTA FE SHOP POINT, APRIL 30TH, 1909.

	Machinists.	Brass Finishers.	Boilermakers.	Blacksmiths.	Cabinet Makers & Coach Carpenters.	Tinners & Coppersmiths.	Patternmakers.	Painters.	Miscellaneous.	Special.	Total.
Topeka	85	3	20	9	18	6	4	13	3	2	168
Shopton	21	..	1	..	..	..	..	..	..	1	23
Newton	22	..	3	..	..	1	..	..	..	..	26
Arkansas City	6	..	1	..	..	..	..	..	..	..	7
Shawnee	1	..	..	..	..	..	..	..	..	..	1
La Junta	17	..	1	1	..	2	..	..	..	..	21
Pueblo	5	..	..	..	..	..	..	..	..	..	5
Raton	19	..	1	..	..	..	..	..	..	..	20
Albuquerque..	20	..	5	1	1	4	..	1	..	1	33
Winslow	1	..	..	..	..	..	..	..	..	..	1
S. Bernardino	28	..	2	..	8	2	..	3	..	1	44
Richmond ...	8	..	4	..	..	2	..	..	..	..	14
Cleburne	31	..	10	3	3	7	..	3	..	..	57
All Schools..	264	8	48	14	30	24	4	20	3	5	420
Argentine ...	1	..	..	..	..	..	..	..	..	..	1
Emporia	3	..	..	..	..	..	..	..	..	..	3
Corwith	1	..	..	..	..	..	..	..	..	..	1
Chanute	4	..	1	..	..	..	..	..	..	..	5
Dodge City..	2	..	..	..	..	..	..	..	..	..	2
Wellington ..	2	..	..	..	..	..	..	..	..	..	2
Canadian ...	1	..	..	..	..	..	..	..	..	..	1
Clovis	3	..	..	..	..	..	..	..	..	..	3
San Marcial.	6	..	..	..	..	..	..	..	..	..	6
Los Angeles.	1	..	..	..	..	..	..	..	..	..	1
Bakersfield ..	2	..	..	1	..	..	..	..	..	..	3
Needles	2	..	..	..	..	..	..	..	..	..	2
Amarillo.....	2	..	..	..	..	..	..	..	..	..	2
Temple	4	..	..	..	..	..	..	..	..	..	4
Silsbee	2	..	..	..	..	..	..	..	..	..	2
Galveston ...	1	..	1	..	..	..	..	..	..	..	2
Somerville ..	1	..	..	..	..	..	..	..	..	..	1
Not in School.	38	..	2	1	..	..	..	..	..	..	41
Total number Apprentices..	302	8	50	15	30	24	4	20	3	5	461

Of the 461 apprentices, 420 receive school as well as shop instruction. There are altogether 11 apprentice schools, 9 school instructors, and 15 shop instructors. One school instructor takes care of Newton and Arkansas City, one serves La Junta, Raton and Pueblo, and at Richmond the same instructor oversees both school and shop work. At Topeka, on the other hand, there is a school instructor and an assistant instructor. The other school points shown have one instructor each. At Topeka there are 8 shop instructors—two on the machine floor, one for machinist apprentices on the erecting floor, and one each in brass-shop, boiler-shop, blacksmith-shop, cabinet-shop and paint-shop. Shopton, Newton, La Junta, Raton, Albuquerque, San Bernardino and Cleburne have one shop instructor each. Schools will shortly be established at Argentine and Chanute under one instructor, and at Clovis and San Marcial under another.

adjustment of relations between the instructor, who is in charge of and responsible for the apprentices, and the master mechanic, who is in charge of and responsible for the product and efficiency of the shop. The cordial approval with which master mechanics all along the road regard the apprentice system, and their active desire to enlarge the enrollment in their own shops, bears sufficient witness to the success with which this last problem has been solved.

This success is the more signal because the line of demarcation between these co-operating authorities is difficult to draw and some diplomacy is necessary. The policy desired is that the foreman shall give all work to the instructor, and let him assign the apprentices to do it; but this is in full force in but few places. In general, however, the system is that the foreman assigns work and the instructor supervises the execution. The object of the whole instructorship system is to get away from the old-time plan, under which a job might be given to a boy without any instructions as to how it should be done; and however earnest the apprentice, he might spoil expensive work in his well-meaning ignorance. The object, therefore, of endeavoring to have the assignment of work by the foreman passed to the boy through the instructor, is to insure against the apprentice being confronted with the alternative of starting upon work he does not understand, or losing much time waiting for his preceptor to arrive. If instructors have to leave the floor they are therefore expected to arrange with foremen or gang foremen to look after the boys temporarily. Reciprocity and harmony of action are strongly encouraged.

The order of instruction in the use of machine tools is standard, subject to some adaptation to local conditions. In general, it proceeds in the following order: baby drill press, heavier drill press, nut facer and bolt cutter, shaper, small lathe, (fitting frame and rod bolts, taper bolts, etc.), heavier lathe (fitting axles, crank pins, bushings), boring mill, and planer. Approximately three months is spent on each machine, but the time necessarily varies with individual ability and aptitude of the pupil.

In order to avoid the discouragement which might come to an apprentice working beside skilled mechanics, especially where differences in efficiency are emphasized by the bonus system, a higher bonus rate is paid to apprentices than to journeymen, 50 per cent being added to the wages of first- and second-year apprentices who attain standard time, and 33 1-3 per cent to the wages of third- and fourth-year apprentices. It has been found that the stimulus of this bonus, combined with the careful oversight and instruction provided,

permits a very good class of work to be assigned to the apprentice with little fear that valuable pieces will be spoiled, and with very fair results in product as compared with skilled mechanics. During the first six months, of course, the boy is not of much value to the company; but during the remainder of his term he more than makes up. Deducting the time spent in class-room instruction, the apprentice in the average will accomplish about 70 per cent as much work as the regular mechanic. The average rate of pay of an apprentice is $1.35 and the average cost of his instruction is about 22 cents a day, making the daily cost to the company $1.57. Considering his output, he is a profitable investment in comparison with the full-paid mechanic at $3.40 to $3.60.

When a boy has completed his time and entered the shops in regular service, his record is reported monthly for the first six months to the supervisor of apprentices, account being given of what and how he is doing, or if he has left, where he went. About 80 per cent of all the apprentices remain in the service, and of those who leave, either before or shortly after graduation, about 50 per cent apply for reinstatement within one year or less.

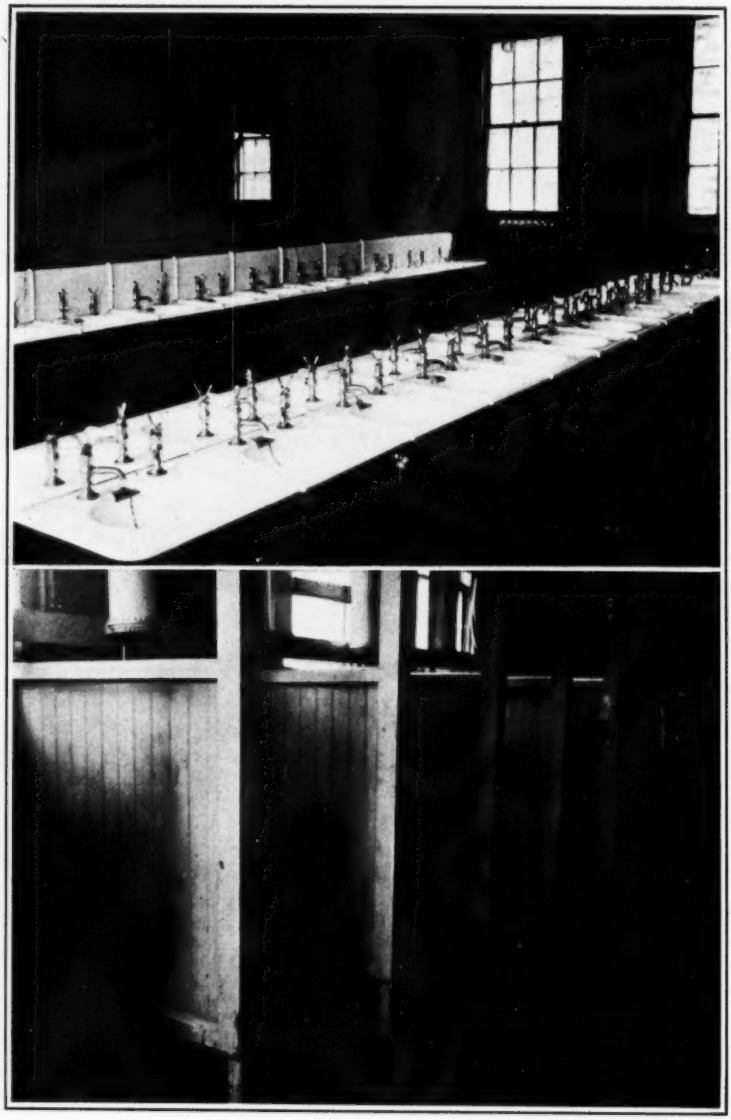
The discharge of an apprentice is considered a very serious matter and rests in the power only of the master mechanic or superintendent of shops, with the final approval of the supervisor of apprentices. The attitude of the road on the subject can not be better expressed than in the words of the master mechanic of one of the largest shops on the Coast Lines. He said: "It is a very serious thing to discharge an apprentice. You take a boy of 16 or 18, keep him in the railroad shops for a couple of years, and you have given him a 'set' that he will not easily lose. Now, if you throw him out he is too old to start over again. The chance is that he will go into rough work—perhaps into degrading work. You may have ruined his life. If a boy hides out or is full of mischief, it often means only that he has qualities which are good if they are turned right. All boys are boys, even in railroad shops. You can generally work out their character for good if you take them right.

"I won't allow any one to discharge a boy. He can recommend the discharge, but I make my own investigation. There are too many human weaknesses and dislikes and favoritisms among the many men in a shop to allow them free play. Often a boy will do little good for a year, or for two or three years, and then in the last of his apprenticeship he turns right around and comes out fine. So I am very slow to act unfavorably on a boy's case because he does not make a good showing at the start."

THE SHOP PARK, NEEDLES, CAL.

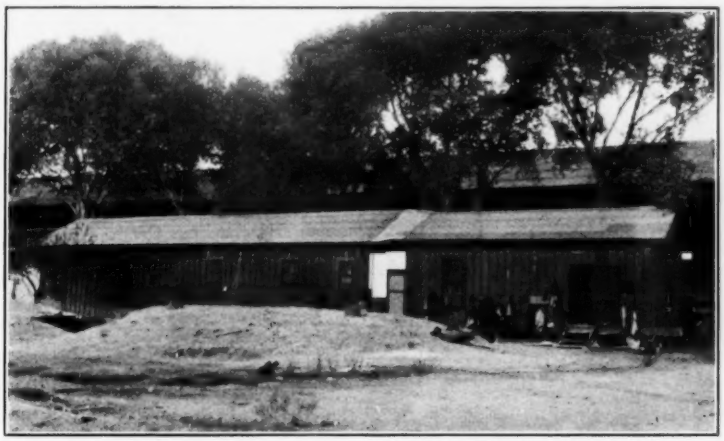
There is none of the arrogance of the administration here, none of the pitiless operation, as of a machine moving in a fixed path without swerve or stop, that is often supposed by outsiders to characterize the conduct of the affairs of a railway. And a few days after the conversation from which the remarks just quoted were taken, I heard the superintendent of shops and the supervisor of apprentices in earnest special conference over the transfer of a sick subordinate to a healthful mountain post where he could regain his strength without impairing his earnings. The Santa Fe system encourages individual efficiency; it also leaves room for the recognition of individual temperament, the consideration of individual needs, and the exercise of a broad humanity.

The personal relations of the road with its employees are generally in the direction of providing for removal of inconveniences directly caused by the environment of the service and beyond the power of the men to control. Whether or not this is the policy deliberately formulated by the road, I believe it is sound and the limitation is wise for any industrial concern. The earliest apparent and most pervasive feature of the Santa Fe practice is cleanliness and attractiveness in and about the shops. Flowers, grass, and shrubbery where they are practicable, whitewash and neatly graded cinders where gentler decoration can not be had, bring the outward aspect of the buildings and grounds up to the best modern standards. Much effort is made, especially in roundhouse floors and pits, to secure ample and quick drainage and to avoid slop and puddles.



WASH ROOM AND TOILET ROOM, SHOPTON, IOWA.

Lockers, wash-rooms and toilet facilities are generally ample and well-kept. The shops are heated and ventilated, and particular effort is made to improve the atmosphere in roundhouses, extending even to partial rebuilding of the roofs of older, ill-designed and ill-ventilated houses. Emergency hospitals, with equipment for the care of accident cases, are installed at all important shops, and a staff instructed in first-aid measures is maintained among the employees and placed immediately in charge of any injured workmen.



SUMMER AND WINTER QUARTERS FOR JAPANESE WORKMEN, NEEDLES, CAL.
The "summer quarters" are in the dug-out in the foreground, which is comfortably fitted up and affords protection from the severe heat. The shade trees in the rear help to the same end.

Going a step farther, the road recognizes the need of wholesome mental and social occupation for men whose hours of work are often extraordinary, sometimes uncertain, and generally alternating with times of unavoidable waiting at points where there is little or no sane and desirable recreation. The reading-room system has been highly developed under its own staff superintendent, and is represented by some kind of an establishment at every division point, the extent and refinement of the plant depending on local conditions and numbers to be served. At the least, it includes a couple of rooms with a selection of books, broad tables for the periodicals and plenty of chairs for readers, provision of the standard magazines and weeklies (both general and technical), some important dailies, and the local papers. Almost always there is a piano, card and billiard tables, and very frequently a bowling alley; a bath-room is the universal adjunct.

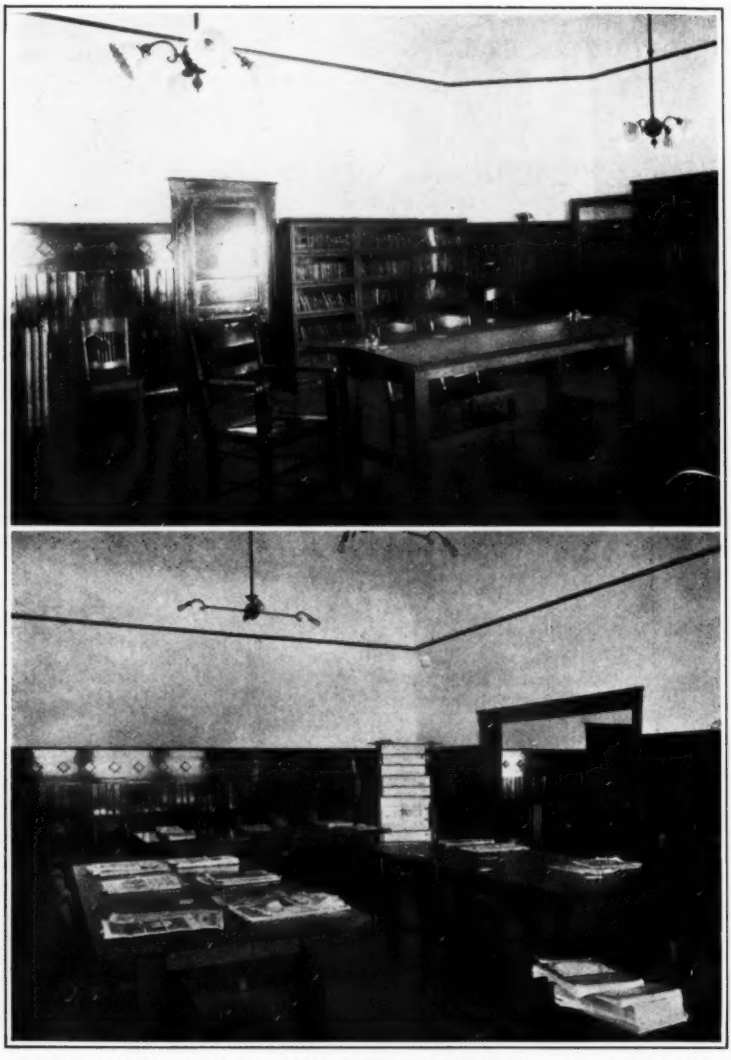
THE NEW SANTA FE RECREATION HALL, NEEDLES, CAL. LARGEST AND FINEST OF THE RECREATION BUILDINGS ON THE SYSTEM.

At larger points a separate building is provided with many of the functions of a club house, and the library assumes fairly good proportions. While the list does not tolerate merely trashy books, it is generously extended to suit the character of the patrons. As one admiring user put it: "The superintendent thinks it's better for a man to be reading even a pretty bad book than to be doing the things he might be doing if he wasn't reading any book at all." Encouragement is given to employees to submit lists of books desired, suggestions of this kind receiving favorable consideration by the superintendent of reading-rooms, and opportunities are also afforded for employees to accumulate libraries of their own,

EMPLOYEES' READING ROOM, RICHMOND, CALIFORNIA. TYPICAL EXAMPLE OF A SMALL PLANT.

by purchase through the reading-room service with the benefit of trade advantages in price thus secured. Both reading and circulating library privileges are absolutely free; it is only necessary for the reader to be properly certified by his superior officer, and to become responsible for books lost or injured while in his possession; for billiards and bowling a trifling charge is made to cover repairs.

Another institution conducted under the auspices of the reading-room officials, and introducing a great deal of pleasure and interest into the lives of the men and their families, is the supply of entertainments (musical, literary and dramatic) during the winter months, especially at small stations where nothing of the kind is offered by



WRITING ROOM AND PERIODICAL ROOM, SANTA FE RECREATION HALL, NEEDLES, CAL.

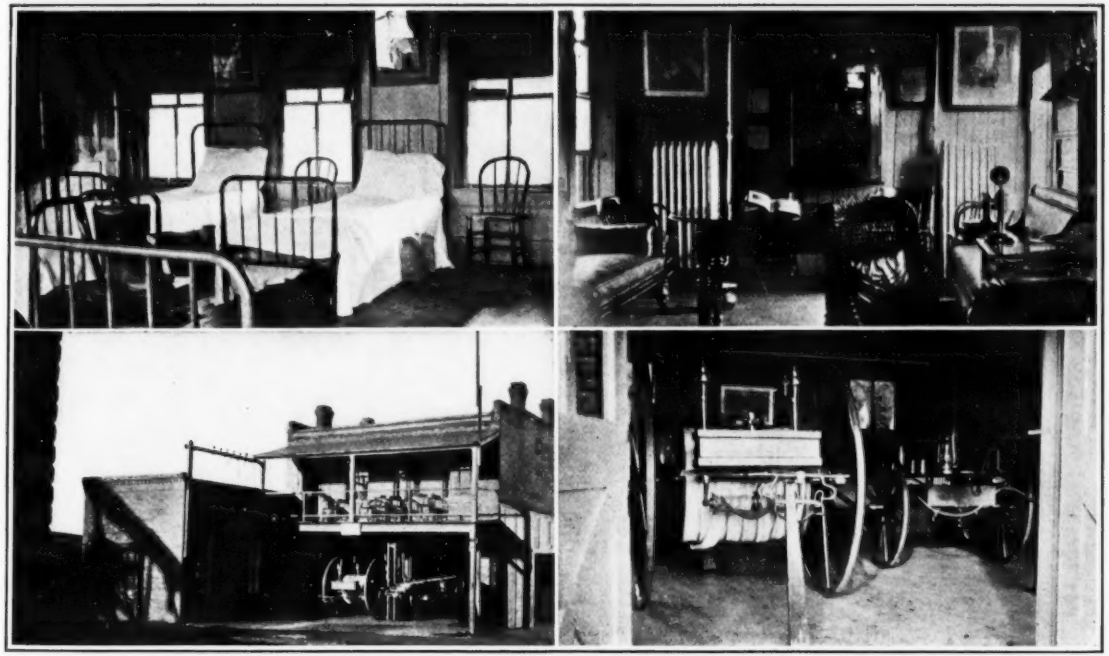
regular amusement agencies. The quality of these performances is excellent, and as they are opened generously to townspeople as well as railroad employees, they become a valuable gift to the communities reached by the railroad. Perhaps only those who have seen and realized the barrenness and deadly starvation of interest in a small desert town can understand how much a provision of this sort can mean for the contentment and satisfaction of those whose work compels them to make these towns their residence. And apart from the direct result in relieving the restlessness and increasing the satisfaction of railroad employees, the Santa Fe officials have found a marked indirect benefit from the institution of the reading-rooms. This comes from the reflex influence on the men, who perhaps unconsciously begin to feel themselves members of a more stable and intellectually better society, and consequently conduct themselves accordingly.

The other institutions of the Santa Fe worthy of special examination are the hospital service and the pension system. Both of these were so thoroughly explained in Mr. Jacobs' article on "The Square Deal to the Railway Employee," which appeared in the issue of this Magazine for June, 1907, that it would be but a repetition to describe them at length here.

Briefly, the hospital system is supported by monthly contributions from every employee and official of the road, the sums ranging from 25 cents to $1 per month. In return it affords unlimited care and treatment in case of injury or illness of the employee or any of his family. The work is carried on by fine central and sufficient local hospitals, a large permanent medical staff, and several hundred affiliated phsyicians and surgeons in the towns along the road. It includes, also, an ambulance service and a first-aid corps among the shop men, regularly enlisted and instructed, with emergency rooms properly equipped at all the larger shops.

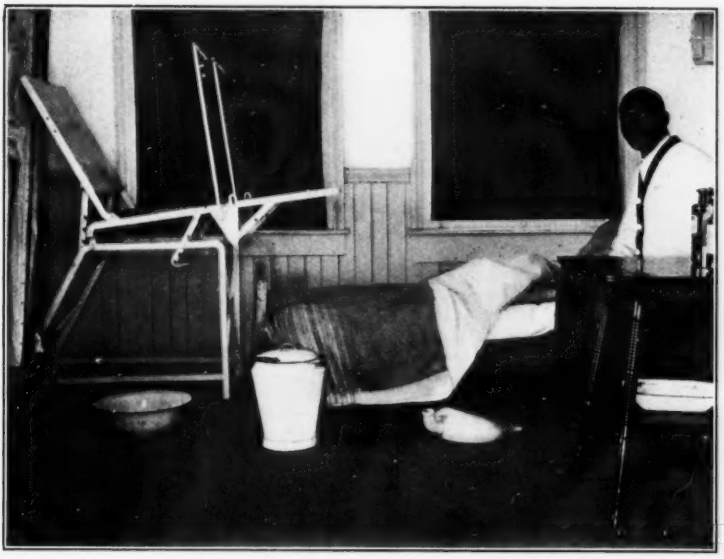
Pensions are granted on retirement at the age of 65, after fifteen years of service, or earlier if the retirement is on account of permanent incapacity for work arising from causes incident to employment. The amount granted is determined by salary and length of service, with a minimum of $20 and a maximum of $75 a month. These pensions are provided wholly at the expense of the company, no subscription to the fund being required from employees.

In conjunction with the measures that have just been explained, these institutions complete a cycle of provisions covering practically the entire period of life during which a man might be in responsible associations with the road. The apprentice courses prepare him for his trade, the bonus system enables him to make an amply good living



GENERAL VIEW OF FIRE STATION HOUSE, TOPEKA SHOPS OF THE SANTA FE, AND INTERIOR OF HOSE-CART ROOM, OFFICE, AND SLEEPING QUARTERS.

The building is centrally located in the shop yards, and houses three carts. Other carts are stationed in smaller houses opening on regular "fire roads" which are always kept open by rigid inspection and discipline. The men in the shop fire department sleep and live here, receiving all accommodation free. The chief is a professional and a regular electric fire-alarm system with many circuits is installed.



INTERIOR VIEW OF SMALL EMERGENCY HOSPITAL, FOR FIRST AID, SAN BERNARDINO.

while he is at work, the reading and recreation rooms furnish him healthful and pleasant diversion during his hours of leisure, the hospital and medical service takes care of him while he is ill or suffering from injury, and the pension provides for him when he is superannuated.

This article closes the review of the principal methods by which the "manufacture of transportation" on the Santa Fe is distinguished. While the spirit of what is usually known as "welfare work" appears most strongly in the reading-room, hospital, and pension systems, the apprentice training and the efficiency and bonus methods of dealing with wage questions are more characteristically distinctive. The largest influence upon economic progress at large is exerted by the bonus plans. This effect is only beginning to be reflected in the financial reports of the Santa Fe, which have recently attracted so much attention. As yet the application is limited (as these articles have been) to the "manufacture of transportation" so far as that lies within the province of the Mechanical Department. The extension of similar ideals and agencies to the conduct of transportation and traffic would open, not only to the Santa Fe but to the railways of the United States at large, vast opportunities for financial betterment and for release from present difficulties—opportunities that are almost

MASTER MECHANICS' OFFICE, SAN BERNARDINO, SHOWING INTRODUCTION OF PARK SYSTEM.
The fire house is next to the office, and the emergency hospital shows on the extreme right.

incalculable in extent. The particular functions of the transportation department touch the public directly and are most conspicuous in the public eye. Low efficiency here (in some of its most subtle forms) is largely responsible for the popular irritation against railways and against their management, which has found expression in much punitive and injurious legislation. Efficiency methods, given free play in the transportation field, would bring in a new era under which a very large fraction of the present problems of the railways—fiscal, physical, and political—would disappear.

The change is not easy nor smooth to make. No upheaval of a long-established order and organization can be free from friction, from misunderstandings, or from hardship on individuals. A railroad organization is inherently an assemblage of strong and positive men, unready to yield their settled convictions easily to every preaching of a new philosophy. The efficiency system minimizes that human or personal element which is most likely to arouse animosity during the introduction and oversight of the requisite changes of procedure; it substitutes the impersonal, but inflexible, testimony and report of times, costs, and results. The merit by which it must eventually convince even the most hesitant, the most reluctant, the most resistant, is that by its organic operation it apportions the benefits of the change so fairly that all those who co-operate must profit by the improvements, each one naturally and indefeasibly according to his own proper share.

THE CHOICE OF HEATING EQUIPMENT FOR MANUFACTURING PLANTS.

By G. W. Stanton.

THE purpose of this article is to describe in general the various types of heating systems, and to define the situations in which each should or should not be used. Only such systems as are applicable to large installations will be considered, as the ordinary appliances usually installed in residences, apartment houses, and the smaller classes of building depend more upon the resources of the owner than upon capability of economical operation.

It is unfortunate that the economical side of the selection and design of heating apparatus has not been given greater thought and study, but the prevalent idea is that so long as it is possible to use the exhaust steam from an engine in a heating system, further economy is impossible; and if that condition is fulfilled, then the only thing that remains is to install the system that costs the least, regardless of what the operating cost may be.

When a large manufacturing plant is to be built, the architects and engineers give a great deal of study to the general arrangement of the buildings so that the manufacturing processes shall be in sequence; that the buildings shall be adapted to their respective uses; that there shall be plenty of light; and they study the arrangement of the machinery from the cranes to the smallest machine tool. Before the boilers, engines and auxiliaries are finally selected and bought, the various types are carefully examined; apparatus purchased must be guaranteed as to efficiency—in short, everything is provided and done that is necessary to a complete and economical plant; that is, all except the heating system. For that no special knowledge is thought necessary, the general idea being that if the engines are non-condensing, then so long as the exhaust steam is utilized in the heating system and the buildings are heated to a sufficient degree of temperature during the coldest weather that occurs in that particular locality, the contract should be given to the lowest bidder, it being considered immaterial in general whether the system be an ordinary low-pressure steam, a vacuum system, a hot-blast, or a forced circula-

tion hot-water, regardless of the fact that only one type of system is best adapted to any particular case.

In office and business buildings, municipal buildings and court houses, schools, libraries, hospitals, and hotels, the conditions complained of do not prevail to the same extent as in industrial plants, where often the power load is in excess of the heating load, and where other factors often combine to make the problem a difficult one, and one demanding a high class of engineering. And this is the main reason for which this article is written—to call attention to the fact that in the proper selection and design of the heating system, or the remodeling of an old one, economies can be effected that will often bring a reduction in operating expense much greater than the increase in the efficiency of the power-generating plant, important as that is.

Another factor that has much to do with the selection and design of the heating system is the deplorable tendency of some engineers to become so dominated by the idea of their own ability that they can see no good in any design except their own, and they think that to recommend any design or system but their own would be a reflection upon their ability as designers, regardless of the fact that often the engineer of the concern submitting the alternate scheme is a specialist, and has a far greater experience and knowledge of the requirements and of details. Then there is the other case where an engineer or architect is biased and becomes wedded to some particular system, specifying that system to the exclusion of all others, irrespective of whether it is or is not the most economical and best adapted for that particular plant.

Considering single buildings where the heating load is the main factor, as in schools, libraries, hospitals, office buildings and small factories, the system to be installed—and the one that usually is—is that using low-pressure steam. In this type of system, exhaust steam is used with a back pressure on the engines varying according to how well the system is designed, and the deficiency in the exhaust steam is supplemented by live steam delivered through a pressure-reducing valve. Such a system, if well designed with mains of ample size proportioned so as to provide a perfect circulation throughout the entire system with one-pound pressure, and to heat the building in very coldest weather with not more than five-pounds pressure, gives good results with a smaller first cost than any other type of system. Of course, there is the same fault with this system as with every other type of steam system—that of heat regulation, which is impossible except by the addition of temperature-regulation apparatus; but this, as it relates to fuel economy, will be taken up later.

Where there is more than one building, and the buildings are widely separated, the low-pressure steam system is not adapted to the conditions, if true economy and first cost be considered; because if it is desired to keep the back pressure on the engine within reasonable limits, then the heating mains must be made very large. On the other hand, if the mains are not properly proportioned for load, friction, and condensation losses, and are made too small, the back pressure on the engine is increased, with a consequent reduction in power and an increase in steam consumption.

It is claimed by some that the addition of a few pounds back pressure makes no difference whatsoever in the coal pile, as all the exhaust steam would be used anyway in the heating system. This is wrong, for in very few plants is the maximum power load less than or equal to the minimum heating load, and only such a condition would give an adequate excuse for installing such a plant. In either case it is bad designing, and such a system is not adapted to the conditions and should not be considered.

There are many types of vacuum systems—so many that it is hard even for heating engineers to keep informed of all—and of these there are but two types that are generally used. One type does nothing but remove the air from the radiators through a system of air pipes, they in turn being connected to a vacuum pump or an ejector. This system is usually installed in office and public buildings and can be added to a heating system without making any changes to the piping in general. Its advantages consist of the removal of the air from the radiators, thus increasing their efficiency; the reduction in sizes of the piping; and the reduction of the back-pressure on the engines because of the vacuum in the system.

In a well designed low-pressure steam-heating plant the addition of such a system is really unnecessary, especially if the automatic air valves are connected to air lines which are connected together and discharged into a sink or tank in the basement, thus doing away with unpleasant odors and escape of steam and water from leaky air valves. With such a steam system, the vacuum system just described would pay but very little, if any, interest on the additional investment, the first cost equalling the saving in the installation due to the reduction in pipe sizes and in radiation; but the system undoubtedly works very well and gives satisfaction, and it could be installed in many heating systems with profit to the owner and comfort to the occupants.

The other type of vacuum system is that in which vacuum valves are placed on the return or condensation ends of the radiators or coils, bottom of risers, and wherever it is necessary to drain the supply

main, and these valves are connected to the return mains which are in turn connected to a vacuum pump. This pump handles all the condensation and places a vacuum on the whole system, and therefore this mode of installation is especially adapted to large plants where otherwise there would be unduly large steam mains. This system is also of value in the remodeling of old steam-heating systems, where, through improper design or growth by piecemeal, the piping is too small, thus necessitating the use of live steam at a high pressure to force a circulation. Under such conditions it makes a good showing in economy and justifies its use. Large economy is claimed for this system because of the vacuum; unfortunately the vacuum is at the wrong end—at the vacuum pump and not at the engine; but while undoubtedly in theory it ought to be more economical than a low-pressure steam, in practice leaky vacuum valves often nullify all the advantages claimed for it. This can be obviated only by the buyer making the contractor installing the system guarantee that the system will operate without the use of a water jet in the main return at the vacuum pump; such a jet condenses steam that is being drawn through leaky vacuum valves, and if the power load is too small and there is not sufficient exhaust steam, live steam is drawn from the boilers through the pressure-reducing valve with a consequent waste of fuel. This system is of greatest value in the remodeling and improving of old or badly designed heating plants, in large installations, and where steam is necessary for other purposes and, therefore, the one set of mains can serve both purposes.

This last feature has often been the deciding point in favor of steam systems over other types, and has been made much of—entirely too much, in my opinion. If the system of heating is one using high-pressure steam with boiler pressure in the mains, then it certainly is advisable to take connections to the various apparatus from these mains, placing reducing valves where necessary. If, however, it is a low-pressure system, then it is advisable to have a separate high- or reduced-pressure system for supplying steam to such apparatus as is in use every day the whole year round, independent of the heating system, and to allow for the raising and lowering of the pressure according to needs; the result will be a saving of the condensation due to over-large mains during the time the heating system is not in use, and a simplification of the mechanical equipment.

Where ventilation is required, it is necessary to use some form of hot-blast or fan system. An installation under this system usually consists of a fan (driven by engine or motor), heater coils, and the necessary air-distributing ducts, which are constructed either of gal-

vanized iron or of brick or concrete. This type of installation is generally found where ventilation is a prime consideration—that is, in buildings such as round-houses, factories or mills employing many operatives, hospitals, schools, public buildings, banks, etc.

The advantages of this system are the concentration of the heating apparatus at one point, the elimination of all piping throughout the building, the ventilation that is afforded, and low first cost of installation. The advantage of ventilation, however, disappears when the air is recirculated over and over again, and the system can then be considered only as a mode of heating simply.

The disadvantages are that it is necessary to operate the fans as long as heat is required (which is often day and night in cold weather), that power is used for driving the fans, and sometimes that the ducts must be of large size. The claim is advanced that if engines are used to drive the fans, and the exhaust steam is turned into the heater coils, the operation of the fans entails no extra cost for power and adds nothing to the running expenses of the plant under this account. This is true only where the heating load is the main factor; if, as in most manufacturing plants, there is already an abundance of exhaust steam for heating purposes, then the advisability of installing this system depends wholly on the weight of the advantages mentioned above, for the cost of operation would be greater than that of any other system. In other words, as much steam will be needed for heating, and to this will be added the steam for the operation of the fan engine and the ventilation. If there is but one building, and that of moderate size, the power used by the fan will not exceed that required by other systems for vacuum or circulating pumps; but if the plant be a large one requiring many fan units, the power needed for the operation of these must be taken into consideration, for it will be an addition to the ordinary load upon the central-station apparatus. Furthermore, (except where there is no exhaust steam, or but little in proportion to the heating load) it is generally preferable to operate the fans by motors rather than by individual engines of large relative steam consumption.

In all buildings in which ventilation is actually required, such as schools, hospitals, etc., the method adopted by many progressive engineers is to have the ventilating system entirely independent of the heating system. That is, in the rooms is placed sufficient direct radiation to take care of the heat losses through the windows and exposed walls and a certain amount of air leakage, the air for ventilation being delivered into the rooms at 70 degrees and in such quantity as is required by the number of occupants, and the purposes for which the

room is used. By this method the temperature of the room can be regulated to any degree desired; and further, in schools and buildings of similar class which are not occupied except for a few hours daily, the fan can be stopped and power saved, and sufficient heat be maintained by the direct radiation to keep the building comfortable.

Another type of heating system that is gaining in favor as its advantages are becoming better known is hot-water heating by forced circulation. By this is meant a system of hot-water heating in which a circulation is induced by means of a pump placed in the circuit of the mains, the water being heated by either exhaust or live steam, or both. The advantages claimed for this system are economy in steam consumption, ease of control, the maintenance of a constant temperature in the building irrespective of the outside temperature, and the ability to run the mains anywhere regardless of grades, thereby permitting the location of the power house at a desirable location. This is often impossible with a steam system unless pumps or other devices are installed to return the condensation if it is desired to save it, or unless expensive tunnels are built.

The disadvantages of this system are that it is necessary to have an independent steam system if steam is required for other purposes (but as before stated, in my mind this is a wise provision and one that conduces to economy in operation); that it requires a greater amount of heating surface than a steam system, and a consequent greater first cost; that it requires greater engineering ability or knowledge in design, (this fact may be disputed, but I know from personal experience that a great deal of the prejudice against this system has been caused by the knowledge of the unsuccessful operation of poorly designed hot-water systems); and that it demands more careful and better installation than the usual type of steam system, to prevent leaks and consequent damage.

It also uses power for the operation of the circulating pumps, but in this it is on a par with vacuum systems and (except in small installations) smaller in its demands than hot-blast systems.

Owing to the circulation being forced, the pipe sizes can be very much smaller than in any type of steam system; where the mains are long this is a distinct advantage. The radiation required is usually 12 per cent in excess of that required for vacuum steam systems, and 20 per cent above that of gravity low-pressure steam systems.

One of the great advantages of this system—and one that deserves consideration—is the ability to control the temperature in the buildings at the power house, besides the individual control of the radiators or coils. That this means much will be conceded when one con-

siders the great variation in temperatures to which residents in the climate of Eastern North America are subjected to. In New York City, for example, the temperature during the heating season ranges from zero to 50 degrees and even higher. As sufficient radiation must be installed to heat the rooms to 70 degrees in zero weather, and as the average temperature for the heating season in New York City is approximately 35 degrees, therefore with a steam system 100 per cent more capacity must be provided for heating than is normally required. Of course, if proper attention could be given to a steam system and the radiation were shut off when the temperature gets above 70 degrees, this excess use would not occur; but unfortunately this close attention is rarely given where there are a great number of radiators or coils, and besides it is so much easier to open a window and let the surplus heat escape, and this is what is usually done.

In the better class of buildings, thermostatic valves are installed on the heat sources, and these regulate the temperature of the rooms by regulating the supply of steam to the radiators; but as such devices are an expense to install and expensive and troublesome to maintain, their installation has been confined generally to the better classes of schools, office buildings, hotels and public buildings, and where first cost is not the only consideration.

It may be asserted that it is possible to obtain a degree of regulation with steam by varying the pressure; but the best results obtainable by such a method depend on the use of high-pressure steam direct from the boiler, and even then it is not advisable to use a greater pressure than 30 pounds in cast-iron radiators. This would give an increase in the temperature of the steam from 212 degrees to 274 degrees, and if exhaust steam is used, would involve the increase of the back pressure on the engines, which is certainly inadvisable unless the engine be small or the engine load light.

The hot-water system is especially applicable to the heating of many widely separated buildings supplied from a central power plant, and where ventilation is required the fans are driven by motors. If hot water is required for lavatory, domestic, or other purposes, that would have to be furnished by a central hot-water lavatory system, the water for this system and also for the heating system being heated by the exhaust steam from the power units and all apparatus centralized in the power house.

This mode of heating has been installed to operate in connection with condensing engines and turbines, the vacuum on the engines or turbines being reduced or increased to correspond to the outdoor temperatures. For instance:

Temperature outdoors. Degrees.	Vacuum in inches at engine.
0	0
10	10
20	16
30	20
40	24
50	26

From the reports of the U. S. Weather Bureau* the following table was compiled, giving the number of hours of different degrees of temperature during a ten-hour working day and on Sundays and holidays during an entire heating season of 200 days.

Outdoor temperature. degrees.	Hours of heating, working days.	Hours of heating, nights, Sundays and holidays.	Total hours per season.
0-10	5	63	68
10-20	95	220	315
20-30	320	675	995
30-40	465	1,124	1,589
40-50	400	920	1,320
50-60	260	270	530
	1,545	3,272	4,817

The time of heating per working day is based on ten hours per day during which exhaust steam is available; during the remainder of the time live steam would have to be used.

Where it is possible to operate the engines condensing, such a combination is certainly most attractive and offers great possibilities in saving of coal through the reduction of steam consumption of the engines during the day, in the saving of live steam, when exhaust steam is not available, by using only just enough live steam to maintain the actual temperature required.

Where turbines are installed this system is especially the one to be installed, for as is well-known the turbine is economically advantageous only when operated under a vacuum. To operate a turbine in conjunction with a steam-heating system, placing 2 to 5 pounds back pressure on the turbine, increases the steam consumption to such a point that a compound reciprocating engine is far more economical in operation. So the designer has been in a quandary as to whether he should sacrifice the steam economy of the turbine or use live steam entirely for heating.

While only a general outline of the engineering possibilities of this particular system has been touched on, yet enough has been shown to make manifest that it is an engineering problem pure and simple. It has received more attention in this review than has been given to other systems because it is not so well known and has not been so thoroughly discussed.

* These temperatures and hours are taken from the report of the U. S. Weather Bureau at Scranton, Pa., and are representative of a large section of the United States.

In some factory plants, conditions are such that the most economical system to install—both as to first cost and operation—is high-pressure steam—that is, a system using steam at 20 to 50-pounds pressure. This condition occurs only where the power load greatly exceeds the heating load and the engines are run condensing, and where calculations show that it would not pay to place a back pressure on the engines and increase the steam consumption; or that it would not be more economical to run with a high vacuum and use live steam in the heating system, varying the pressure by means of the pressure-reducing valve to suit the outside temperature. If proper attention is given to such a heating system and the piping is designed to operate with the lowest pressure to be used, satisfactory regulation can be obtained; for steam at 60-pounds pressure has a temperature of 307 degrees and at 20-pounds the temperature is 259 degrees, leaving a considerable range between these extremes. With such a system it is advisable to use coil surface only, as the steam pressure would be too high for the ordinary type of cast-iron radiators.

In this article I have endeavored to give an outline of the various systems of heating in general use and their advantages and disadvantages as I see them. I have endeavored to be fair to each type, but I am sure that many will disagree with the conclusions. If, however, this article shall cause more attention and study to be given to a generally neglected and overlooked but very important adjunct to every power plant, and if it leads to proper study and consideration of all factors before additional boilers and engines are added when the power plant becomes overloaded, then I shall be satisfied.

That this phase of industrial engineering has been generally overlooked or neglected I know from personal experience. For instance, a large manufacturing plant in Massachusetts, known the world over for the high class of engineering and quality of its product, bought its power from the local electric generating plant and used live steam entirely for heating. The condensation from the heating system was wasted—discharged into a neighboring canal, and for years no thought was given to the enormous waste. Some few years ago the heating system was entirely remodeled and made a central station, using the exhaust from an air compressor, hydraulic pump, and boiler-feed pump, all condensation being saved and live steam used only when there was not sufficient exhaust steam. The resultant saving was between $8,000 and $9,000 per annum, paying 17 per cent on the cost of changes. This particular case was rather flagrant, but there are many, even plants in charge of trained engineers.

SCENE AT A LARGE FREIGHT TERMINAL IN NEW YORK HARBOR.

THREE-TRACK AND TWO-TRACK CAR-FLOATS IN POSITION TO RECEIVE CARS FROM THE RAILWAY YARD.

FREIGHT-HANDLING EQUIPMENT.

AN ANALYSIS OF MODERN PRACTICE.

By Werner Broecklin.

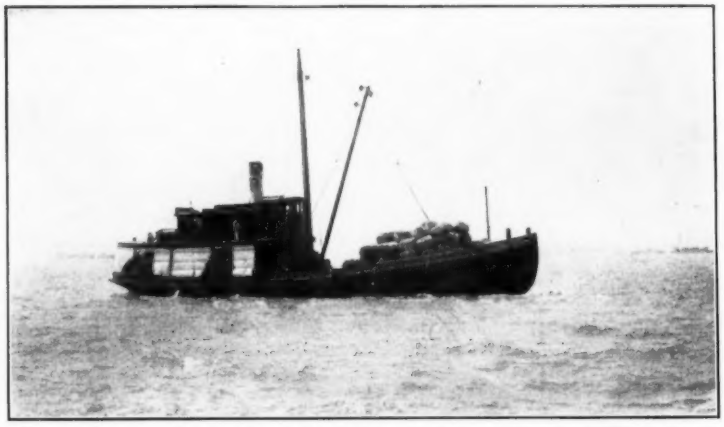
Mr. Boecklin's article is valuable as a descriptive record of some of the most interesting special applications of mechanical handling; but a further and larger value lies in his suggestions of great possible extensions in mechanical construction and the use of machinery, by which the economy of freight transportation may be immensely improved.—THE EDITOR.

DIFFERENT cities have solved the freight-handling problem in various manners, each suited to the conditions in an individual case; it is not often possible to adapt the methods used in one place to the requirements of another.

For example, St. Louis has a great central terminal known as Cupples Station. This station consists of a series of large buildings of the warehouse type, located in a terminal yard covering a large area, and having connection with all trunk lines entering the city. Spur tracks run into the buildings and freight is unloaded and delivered to the consignees' floor by hydraulic elevators. In like manner freight is re-shipped, and all handling is done by employees of the station whose wages are paid by the firms occupying the buildings collectively. Expensive trucking is in this way eliminated and the freight business is contracted into the smallest possible space.

In Chicago another solution has been sought. Here the trucking service, instead of being eliminated, is transformed by the construction of a series of tunnels in which small freight cars electrically operated transfer freight from point to point.

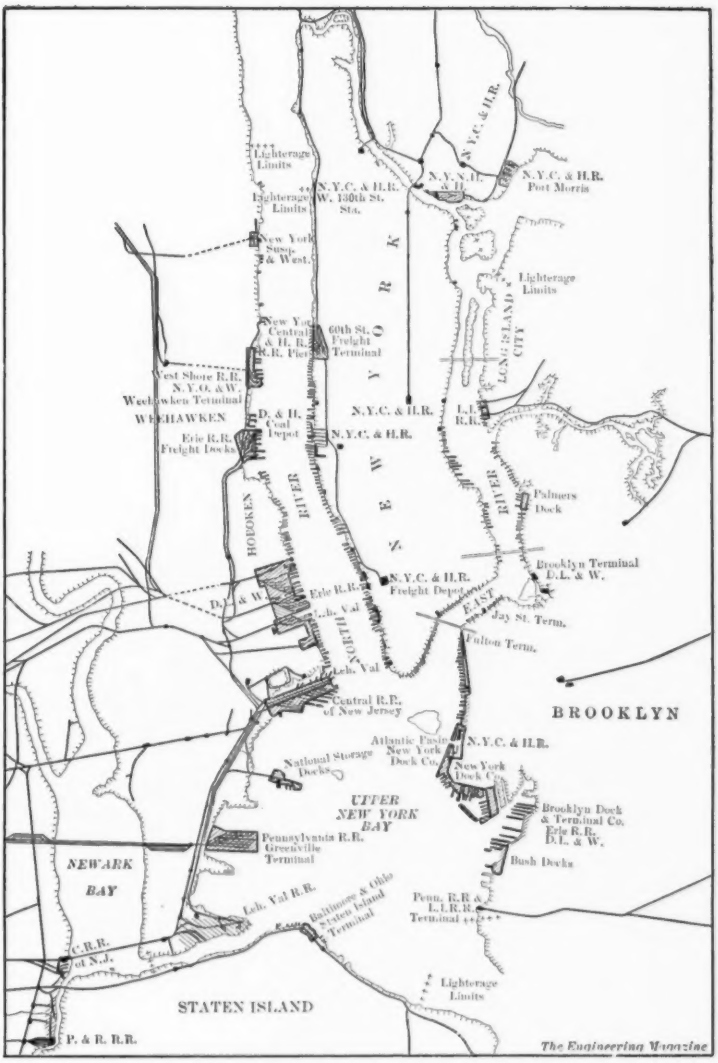
New York's insular location introduces difficulties met with in no other city of like importance. There are a dozen trunk lines having terminals at New York's seaboard. Of these the New York Central has rail connection with its piers and freight houses at 60th street, 33d street, and St. John's Park, and is the only road having such facilities on Manhattan Island. The New York, New Haven & Hartford operates a terminal station on the Harlem river, in the Bronx, and the Baltimore & Ohio has a large freight terminal yard at St. George, Staten Island. With these exceptions the great trunk lines receive and ship freight at their terminal yards located along the New Jersey shore. Facilities must be provided at these points for receiving and holding from 400 to 2,000 cars, for unloading and forwarding of freight, or for forwarding cars with seals unbroken. The methods employed to accomplish the distribution of the thousands of tons of freight entering and leaving the port daily constitute a special line of industrial activity which may be classed under the generic name "Local Freight Transportation."



STEAM TUG WITH MAST AND GAFF RIG FOR HANDLING FREIGHT.

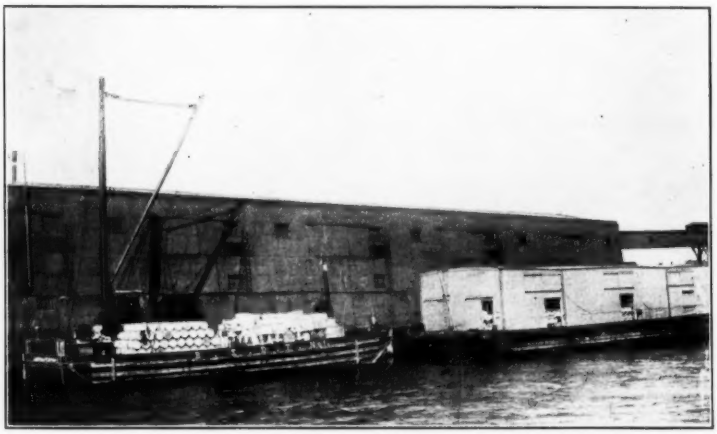
A characteristic feature of New York's lighterage methods.

Lighterage facilities make possible the handling and moving of freight within the area under consideration. The term "lighterage" was originally applied to the transporting of goods from vessel to shore by means of small boats, and the method was resorted to where the water was too shallow to permit a landing, or where no facilities existed for berthing a ship. In the modern



MAP SHOWING NEW YORK AND NEIGHBORING WATERS, WITH SOME OF THE PRINCIPAL FREIGHT TERMINALS.

acceptation of the term, goods transported by means of "barges," "lighters," car "floats" or "tugs" are said to be lightered. Lighterage as a business came into existence in the year 1841, when the New York & Erie Railroad opened from Piermont to Goshen, and freight was transported by open barge in the latter part of that year. The Pennsylvania Railroad was the first road entering New York to own and operate its own lighterage equipment. The original boats of this class were sail-rigged, and some of these are still actively employed alongside of the modern steam-propelled craft.

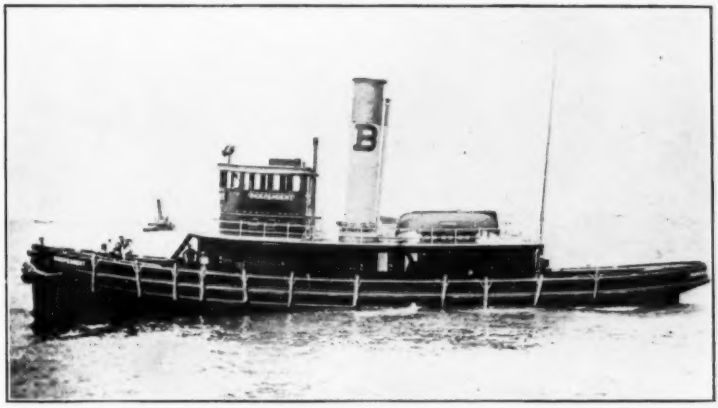


STANDARD OPEN BARGE WITH HAND-OPERATED HOISTING RIG, AND COVERED BARGE FOR GOODS REQUIRING PROTECTION FROM THE WEATHER.

Each railroad has its Lighterage or Marine Department, which has to do with all matters pertaining to the transportation of freight by means of its floating equipment. The New York Central operates 254 vessels in the harbor of New York. Included in the list are 21 tugboats; 7 self-propelling freight lighters; 35 power and hand-hoisting barges with an aggregate carrying capacity of 9,500 tons; 96 covered barges used for the transportation of perishable freight, and having an aggregate carrying capacity of 24,000 tons; 38 grain boats of 18,720 tons total capacity, and 45 car floats capable of moving 544 cars or 13 freight trains averaging 40 cars each. The Delaware, Lackawanna & Western has a lighterage equipment of some 20,000 tons carrying capacity, exclusive of 26 car floats capable of transporting 294 cars. The Erie has an equipment of 460 vessels, the Central Railroad of New Jersey has one of some 200 vessels.

In addition to the dozen railroads using tugs, lighters, barges, etc., for moving freight from one point in the harbor to another, there are some thirty independent companies engaged in the lighterage business. All told, the fleet operating in New York waters is an impressive one, amounting to fully 1,800 vessels of various types. An idea of the total invested capital may be gained when it is stated that the value of one fleet, that of the New York Central, is close to $2,500,000. In the year 1900 this one road lightered 1,250,000 tons of merchandise freight, 59,000,000 bushels of grain, and towed 190,000 carloads of freight, equivalent to 4,750 trains of 40 cars each.

A sail down the bay or up the North or East rivers on any clear day will convince the observer of the diversified conditions existing in the freight-transporting business in Greater New York.



TYPICAL TUG FOR HARBOR TOWING.

Such a boat, of 1,200 horse-power, can tow two of the largest car floats, transferring a total of 43 to 50 cars.

The movement of freight via local routes is accomplished largely through the medium of steam tugs. These occupy upon the water a position analogous to that of a switch engine in a freight yard, shunting floats or barges from point to point as the engine moves cars from the receiving yard to the unloading track. Loading and unloading points are lined along the shores of the two rivers, the upper bay, the Harlem, and Kill Von Kull, totaling some 770 piers, of which 300 are in Manhattan, 200 are in Brooklyn, 140 are in Staten Island, and the remainder are in Queens and the Bronx. Here are open wharves reaching out into the

river, piers covered by steel or wooden sheds where freight is temporarily stored and protected from the elements, transfer bridges for passing cars from floats to yard or vice versa, and storage warehouses where freight is held for an indefinite length of time.

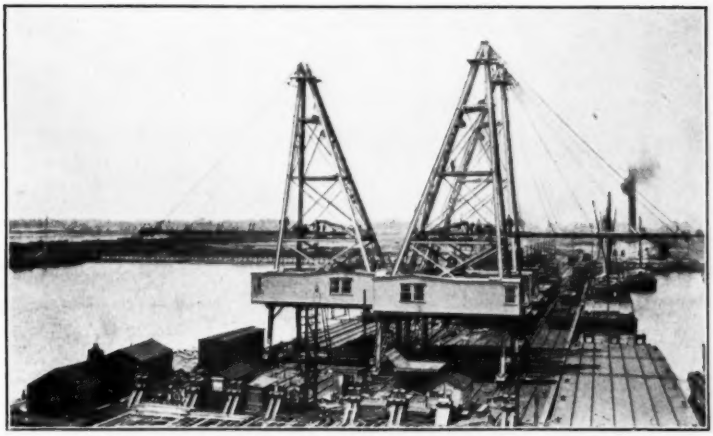
Lighters, barges, and other craft employed in the carrying business are equipped either with hand or power hoists, and this machinery used alone or in conjunction with mechanical methods on the docks and piers, effects large economies of time and money. A few piers are equipped with some form of traveling crane. There are serviceable machines in the case of open wharves, being designed to span their width and to pass over the

COVERED PIERS, 1,500 FEET LONG, FOR TRANSFERRING FREIGHT FROM RAILWAY CARS TO VESSELS.

car tracks laid along them. Using such an equipment, cars are readily unloaded, the freight being hoisted, trolleyed, and transported to the barge or lighter alongside, all the movements under the control of a single operator. The Greenville Terminal of the Pennsylvania Railroad has three steeple gantry cranes, having a hoisting capacity of 10 tons and spanning five tracks on the piers.

The Central Railroad of New Jersey operates two smaller machines of the gantry type.

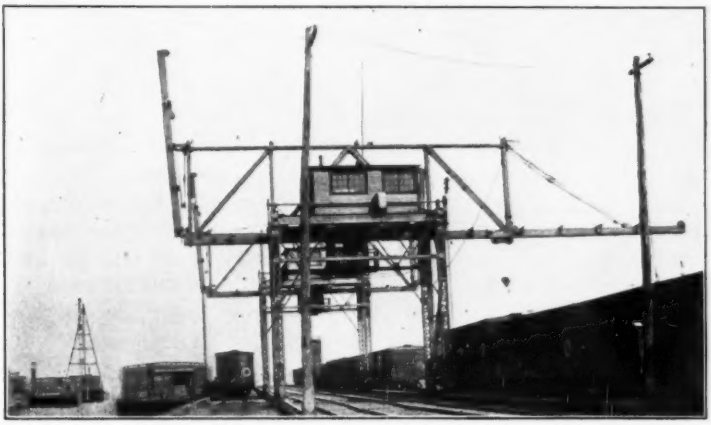
In the case of a consignment of four cars of bar iron, for example, to be delivered alongside in Manhattan or Brooklyn, while the crane is unloading one car and running down the pier



TRAVELING HOISTS, GREENVILLE PIERS OF THE PENNSYLVANIA RAILWAY.

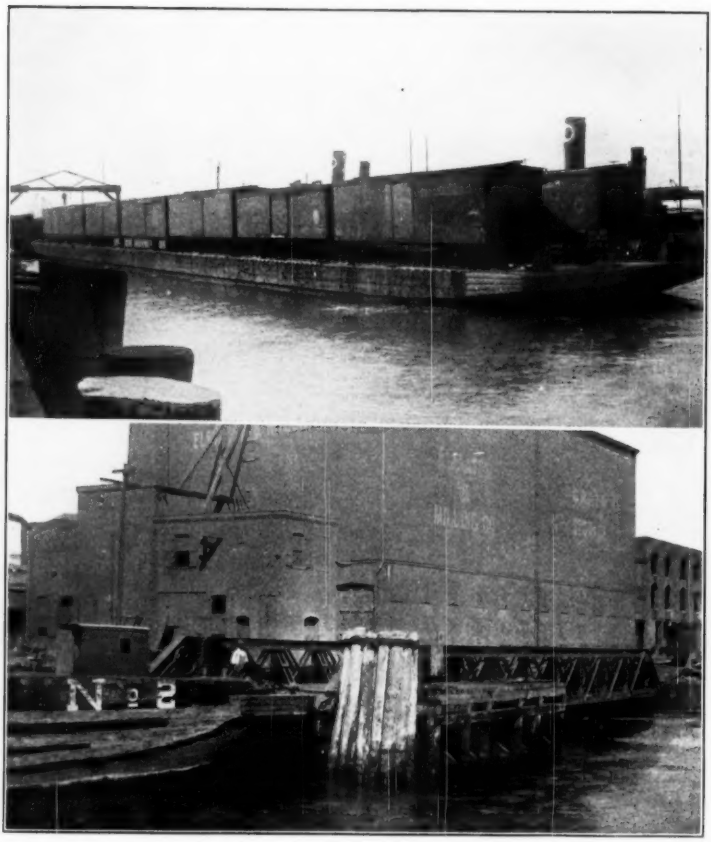
Installed by the C. W. Hunt Co., for handling heavy freight.

to deposit material on deck of a lighter, the latter, being equipped with power hoist and boom derrick, can be unloading the car which lies next to it. The machines alternating in this manner cause no interference and a great saving in time and labor is secured.



TRAVELING GANTRY CRANE, CONTROLLING FOUR TRACKS.

A covered barge is seen alongside, loading with goods taken from the car. The cars on the opposite side are being unloaded.



MODERN STEEL CAR-FLOAT, AND TRANSFER BRIDGE FOR LOADING IT.

The float has three tracks, holding 23 cars. In the lower picture the transfer bridge is shown connected with the barge, in position for loading the cars.

The car float makes possible one of the most economical methods of transferring freight. There are two types; one carries twelve 34-foot cars on two tracks with an unloading platform between them; the other, which is constructed entirely of steel and is over 300 feet in length, has three tracks carrying twenty-three 50-ton cars. In the first class, the cars are unloaded as they stand upon the float, freight being trucked over the platform to

the dock. The second class is used as a connecting link for the interchange of cars destined for points beyond New York, or for transfer of cars between a rail terminal and one of the many interchange points.

INTERIOR OF A NEW YORK FREIGHT-SHED.

The goods, received from steamers, are ready for removal by consignees' trucks.

Another important factor in the economical handling of freight is the storage warehouse. To understand its function, let us take the case of a local dry goods merchant receiving a consignment of fabrics. The goods, we will say, amount to a car load and the car is ticketed for a certain pier in New York. The car being lightered via "float," the goods are removed and placed upon the floor of the pier, whence they are taken by the owner's truckmen and carted across the city to be stored until needed. Assuming that a major part of these goods are to be reshipped to foreign points, this amount is taken from the stock room, again carted over the city, delivered to the pier, lightered, and loaded on car or steamer for destination. The rehandling is essential; but how about the trucking? If it were possible to cut the cost of trucking in any way, then the cost to consumer would be reduced. Failing in this, more radical measures may be adopted and trucking done away with entirely, by moving the store-room down to the water's edge.

STORAGE WAREHOUSES ON THE NEW YORK WATER-FRONT.

The warehouses shown above use electric hoists for handling the freight. In the hay warehouse, below, each bay has its hoisting equipment operated from a line shaft running the full length of the building.

This has been done at a number of points in the harbor, buildings having been constructed contiguous to the piers in which merchants may lease space for the storage of goods. The New York Dock Co., the Brooklyn Dock & Terminal Co., the Bush Docks, the Fulton Terminal, Jay Street Terminal, the Harlem

Transfer Co., Palmer's Dock, and Wright's Dock, are thus equipped for the accommodation of local merchants.

Terminals of this class must of necessity be confined to localities where land values are not prohibitive and where there is opportunity for the storage of cars. Manhattan Island offers no such conditions, Long Island, New Jersey and the Bronx being the only available sections. On the New Jersey shore are located most of the freight yards of the great trunk lines, and the construction of large terminal warehouses with unloading piers and all accessories would seriously interfere with the proper operation of their yards. Hence it is that the great central distributing terminals are located in Brooklyn and in the Bronx.

BUSH TERMINAL, SHOWING THREE PIERS.

Ocean-going vessels and harbor barges are transferring freight.

The Bush Terminal Co. occupies some 200 acres of water-front property in South Brooklyn, where it has built a group of six covered piers, each about 1,500 feet in length, two float bridges for the transfer of cars, a storage yard with a capacity of 1,500 cars, 123 storage warehouses, and a power plant for the generation of light, heat, and power. Tracks extend along each pier and connect with the freight yard and warehouses. The latter are equipped with electric elevators and hoists to facilitate the

STORAGE YARD (1,500 CARS CAPACITY) AND WAREHOUSES, BUSH TERMINAL.

placing of stock in or removing it from the different floors. Protection from fire is afforded by a complete fire-fighting system installed throughout the plant.

Freight shipped via one of the trunk lines having piers in New Jersey will be ticketed for said piers with final destination in harbor indicated on the ticket. With the exception of certain restricted freight, such as articles of an inflammable or hazardous nature, and those of a heavy or bulky character, a charge is made to cover the expense of "lighterage" or "floatage" of 3 cents per 100 pounds less than the through rate. As an example: weight 15,000 pounds, through rate 10 cents.

To Jersey City, 7 cents	$10.50
Lighterage, 3 cents	4.50

The term "free lighterage" means that the freight is to be lightered to points within the lighterage limits without any charge beyond the regular New York rates.

For transferring freight cars by floats between rail termini and float bridges within the free-lighterage limits, charges are made ranging from $4.50 to $6 a car.

The treatment of this subject would not be complete unless passing reference at least were made to two classes of freight constituting a large proportion of the total annual freight handling business of greater New York. In 1908 32,000,000 bushels of grain and 30,000,000 tons of coal passed through this port. Certain salient features may be mentioned bearing particularly upon the development of mechanical means for handling these materials.

Readers familiar with the sights of New York harbor have often seen the floating grain elevator discharging its cargo into the hold of some big ocean-going vessel. Pagan's Patent grain elevator came from Troy in 1848 and at once established for itself

FLOATING GRAIN ELEVATOR TRANSFERRING FROM CANAL BOATS TO STEAMER.

Capacity 1,500 bushels an hour. Elevator is equipped with cyclone blowers for cleaning the grain.

an unenviable reputation. Previous to the advent of this automatic machine, grain had been transferred to ships by the good old-fashioned method of "toting" and 600 bushels per hour was the record. To have a machine step in and handle 2,500 bushels, besides cleaning the grain, was more than any self-respecting stevedore of those times could stand for, and after bitter opposition on the part of labor and after many threats had been made against the owners, a fire of incendiary origin destroyed the elevator as it lay at its dock in Brooklyn. Four years later another floating elevator was placed in operation. Its capacity was nearly double that of Pagan's, while the modern machine transfers 12,000 to 18,000 bushels of grain per hour from canal boat to steamer.

The larger percentage of the coal handling in the port of New York is done by mechanical means. From the time of its discharge from cars at the various coal ports into barges for lighterage to points of distribution and consumption, bucket hoists, cable railways, and conveyors become chief factors in reducing the cost of handling. The floating grain elevator has its counterpart in the harbor's coal trade in the floating coal-weighing barge. A vessel of this class has a carrying capacity of 1,000 tons and is equipped with a bucket conveyor for transferring coal to the holds of ocean-going vessels, handling in this manner about 40 tons an hour.

To handle New York's freight by a combination of the central terminal and tunnel plans suggests a feasible solution of the problem. To develop the central terminal scheme the acquisition of properties in New Jersey offers a key for a comprehensive plan. Such a terminal must hold the loaded freight for transfer to steamers, amounting in some instances to one or two hundred car loads for a single vessel, and empties for the various trunk lines for the receipt of cargo freight. New Jersey is the only available locality where both sufficient ground area and direct connection with the trunk lines can be secured. To complete the system a series of tunnels would have to be constructed to bring transfer points and local freight-receiving stations in Manhattan, Brooklyn, and the Bronx within the working zone. Recent tunnel and subway construction in New York serves to bring such a proposition within the range of possibility, offering as it does a working basis for exact estimates not heretofore accessible.

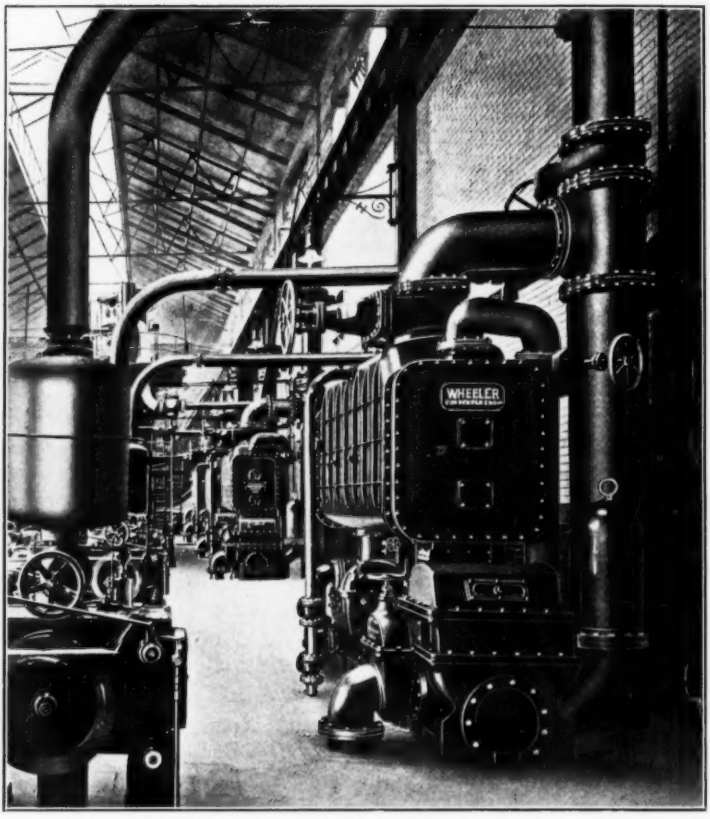
STEAM-CONDENSER DESIGN AND PRACTICE.

By Dr. Jos. H. Hart.

THE use of condensers as an aid to steam-engine efficiency is becoming common in smaller and smaller installations, and practically every engineer is more or less familiar with the fundamental ideas involved in the operation and theory of the ordinary steam condenser. Comparatively few, however, are familiar with many of the more serious problems which enter into condenser construction and design, and the great specialization existing in the various types, depending upon conditions of utilization and duty to be performed. The classification of condensers into jet and surface types, and the dependence of a choice between these upon character of water is more or less familiar, but the other classifications into types as best fitted for special purposes, their relative efficiencies in regard to water consumption and overload possibilities, their reliability, and various other questions of maintenance and operation, are constantly undergoing change to such an extent that the field of steam condensation as a branch of steam engineering is acquiring greater and greater significance.

Thus, the necessity of special design for more efficient operation in the utilization of condensers in turbine installations is well understood, but the difficulties met with in these re-adjustments, and their methods of solution, are not so familiar. In order to understand this more clearly, we cannot do better than to review briefly condenser design in general, and the specific problems met with in actual operation, with a short study of general efficiency.

Condensers can be divided into two classes, the jet and surface types respectively, dependent for their utilization upon the character of the condenser water; and all the differences in these two types are dependent upon the necessity of separation of the water of condensation from the steam and the water used in producing condensation. Again, jet condensers can be divided into various types, according to the methods of maintenance of the water seal for the vacuum, the procedure involved in the circula-



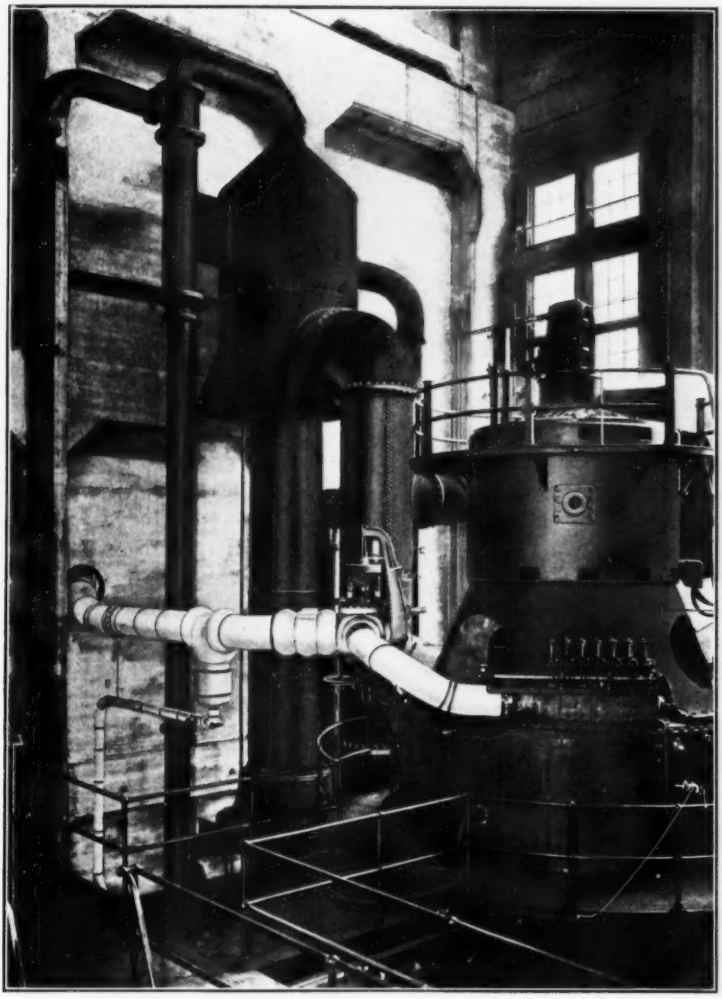
FOUR ADMIRALTY SURFACE CONDENSERS, SHEFFIELD CORPORATION ELECTRICITY WORKS.

Installed by Wheeler Condenser & Engineering Co., to operate in connection with 10,000 horse-power of cross-compound engines.

tion of the water, and the removal of the air carried into the condenser by both the steam and the condenser water. The various distinctions involved in these classifications will come out more readily by a brief review of the various types existing on the market.

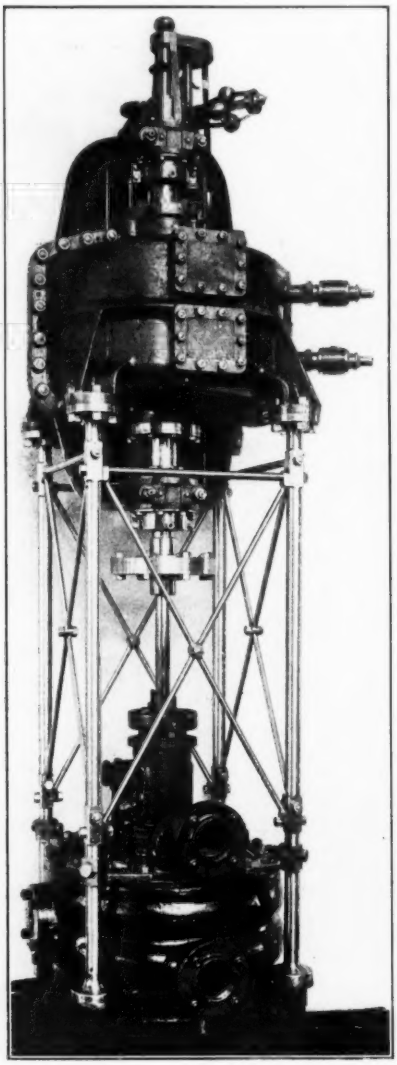
The surface condenser consists practically of a steam boiler, as far as design is concerned, and is equivalent more especially to what is known as a shell-cooler in refrigeration. The object desired is to bring the steam for condensation into as intimate and continuous contact as possible with the cold water without allow-

ing their absolute mixture. This is accomplished in the majority of cases by having a bank of pipes, or a nest of boiler tubes, installed in a metallic shell and possessing two separate and distinct circulating systems, one for the cold water and the other for the



WEISS COUNTER-CURRENT CONDENSER FOR 3,000-KILOWATT TURBINE, SEATTLE ELECTRIC COMPANY.

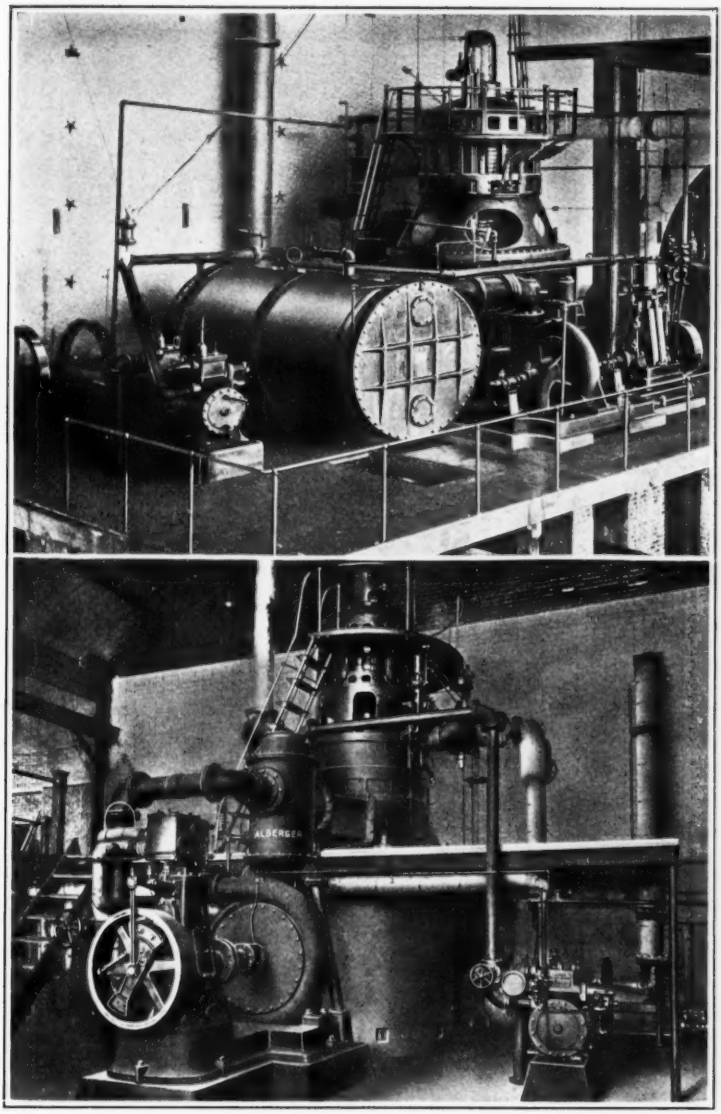
Southwark Foundry & Machine Co.



VERTICAL TWO-STAGE TURBINE HOT-WELL PUMP, 4-INCH, DRIVEN BY STEAM TURBINE.

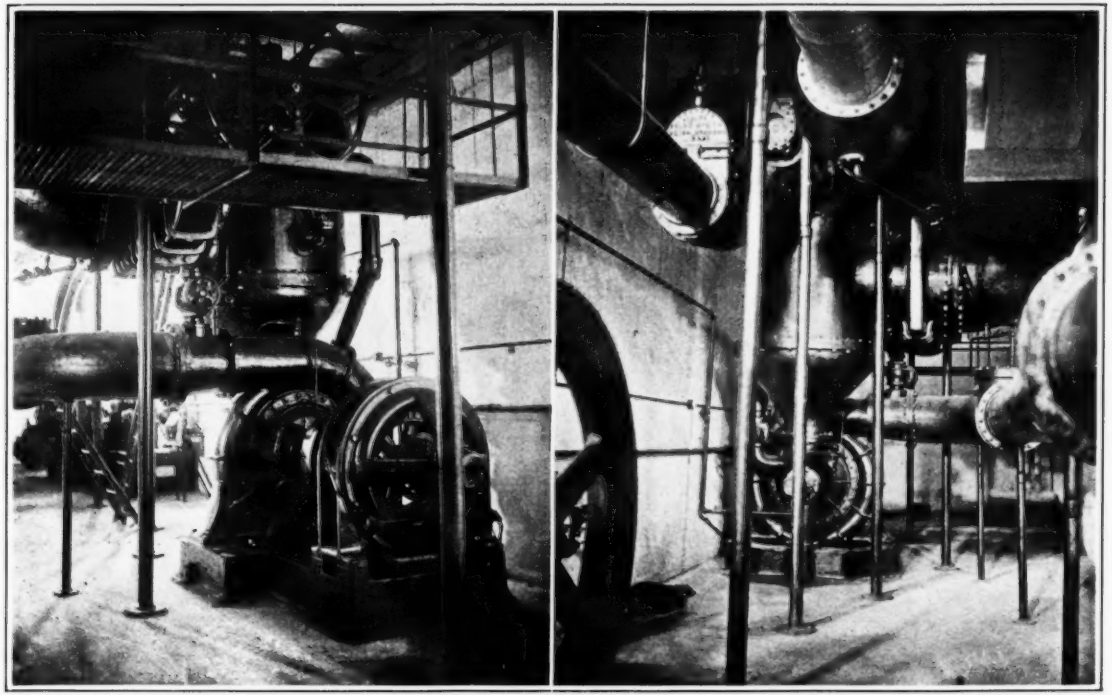
For surface condensers under high vacuum. Installed on new American scout cruisers. Henry R. Worthington.

steam, with great possibilities of transferring heat through the extensive surfaces. As can be readily imagined, this construction allows a wide variation in theory and design for the best utilization of the cold water and most rapid condensation of the steam. Counter-current, multiple-current, and parallel-current types exist, with diverse opinions in regard to relative efficiency. The air must be removed by means of a vacuum pump, in this type, and the water of condensation from the steam can be pumped back directly through a feed-water heater into the boiler and used over again. Problems arising from contact with the external air, and the pressure exerted by it, and those due to the variability of temperature and pressure conditions on the condenser water, are eliminated. Thus, the possibility of having the condenser water become so hot that it boils spontaneously on account of the reduced vacuum, is a problem not met with in this form of construction. This latter condition limits the heating range for condenser water in the jet or barometric type, but only enters in-



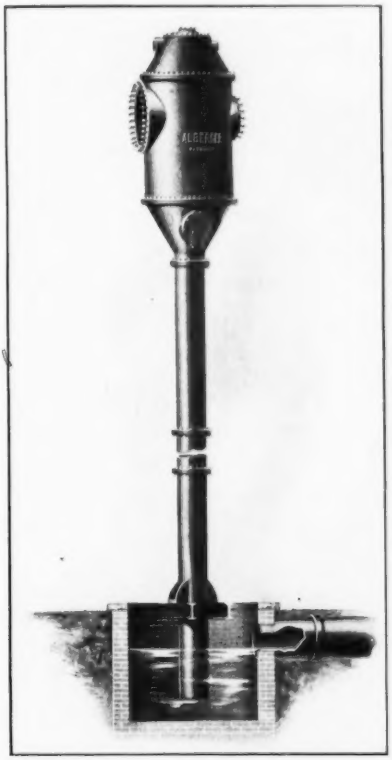
ALBERGER CONDENSER INSTALLATIONS WITH CURTIS TURBINES.

Above, counter-current surface condenser for 2,500-kilowatt turbine, Denver Gas & Electric Co. Below, centrifugal condenser with 500-kilowatt turbine, Port Huron Light & Power Co.



TWO VIEWS OF COUNTER-CURRENT JET CONDENSER INSTALLATION WITH ELECTRIC-DRIVEN CENTRIFUGAL PUMP, UNITED ELECTRIC LIGHT CO., SPRINGFIELD, MASS.

Installed by Deane Steam Pump Co. for a 2,500-kilowatt Parsons Turbine.

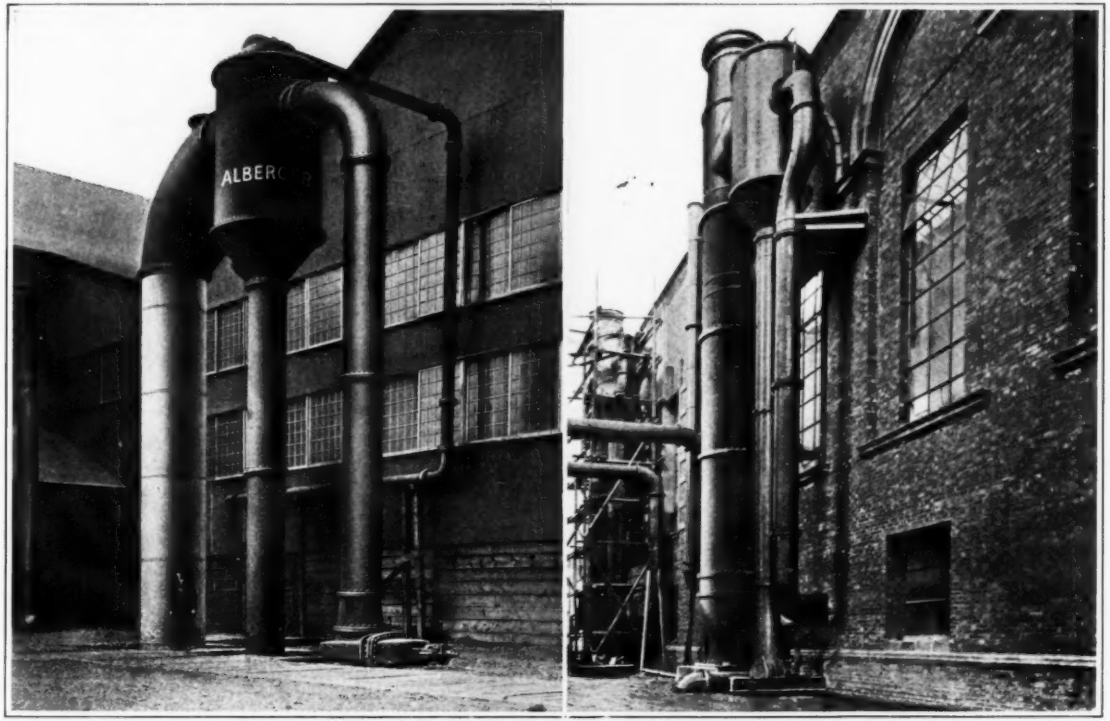


ELEVATION OF BAROMETRIC CONDENSER, SHOWING SELF-SUPPORTING CONSTRUCTION.

Alberger Condenser Co.

directly into the surface condenser. In the latter, the water of condensation may possibly boil at the diminished vacuum if it is not removed with sufficient rapidity, or kept cool by the circulating water. The cooling water itself, however, is not affected by the range in temperature except under extreme conditions. As a general thing the water in surface condensers can be raised to a considerably higher temperature in the performance of their duty, but they require comparatively large installations with great heating or cooling surfaces, since the efficiency of heat transfer is much less in this type.

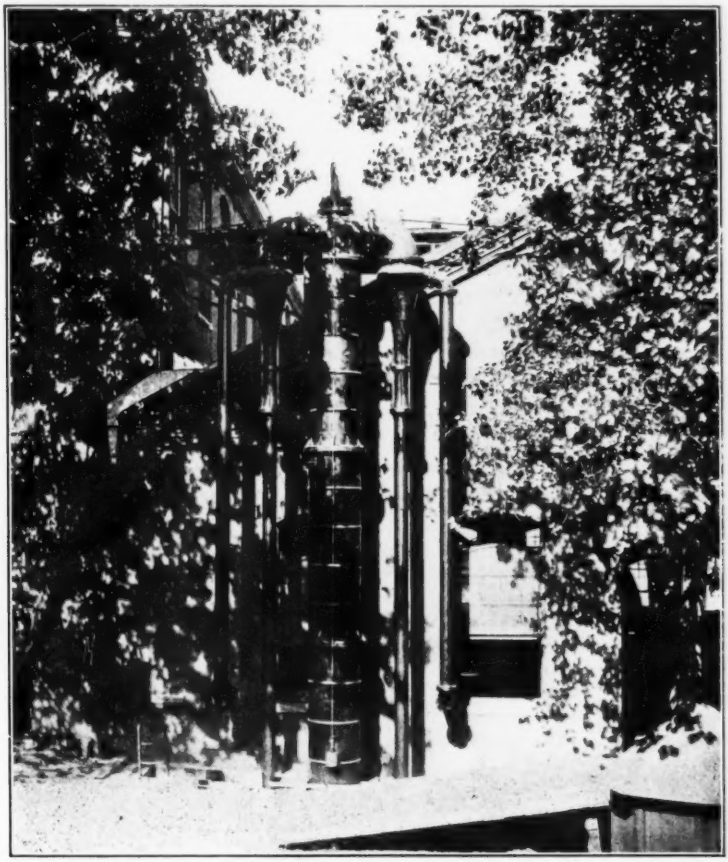
Jet or barometric condensers are based in principle upon the immediate, intimate contact of the steam and condenser water, directly in the vacuum, and they necessitate the removal of this water as fast as it becomes unserviceable through excessive heating, and its renewal from a suitable source. In actual design and constructive details, the jet condenser with pump attachment is undoubtedly the simplest of all types. It is much smaller for a given capacity than any other construction, but its efficiency is often limited. The jet condenser for the circulation of the water requires the insertion of a water seal (and in reality, two of these) against atmospheric pressure. This sealing may be accomplished by the aid of a column of water, able to exert a pressure equivalent to that of the atmosphere, on a principle similar to that involved



ALBERGER BAROMETRIC CONDENSERS.

The Neasden installation, on the right, includes four of the condensers in connection with four 3,500-kilowatt Westinghouse-Parsons turbines. The installation on the left is one of two 10,000 horse-power central condensers at the Bethlehem Steel Works.

in the operation of an ordinary barometer. This explains the necessity in some cases of an installation including stand pipes 30 to 35 feet high, or a sunken well of this depth for the maintenance of the different levels. A condenser using this barometric column consists in reality of two water barometers, connected at the top into a single vacuum chamber into which the exhaust steam is turned. In order to promote a water circulation, it is necessary only to raise the water in one of the tubes, whereupon it will automatically flow out of the other.

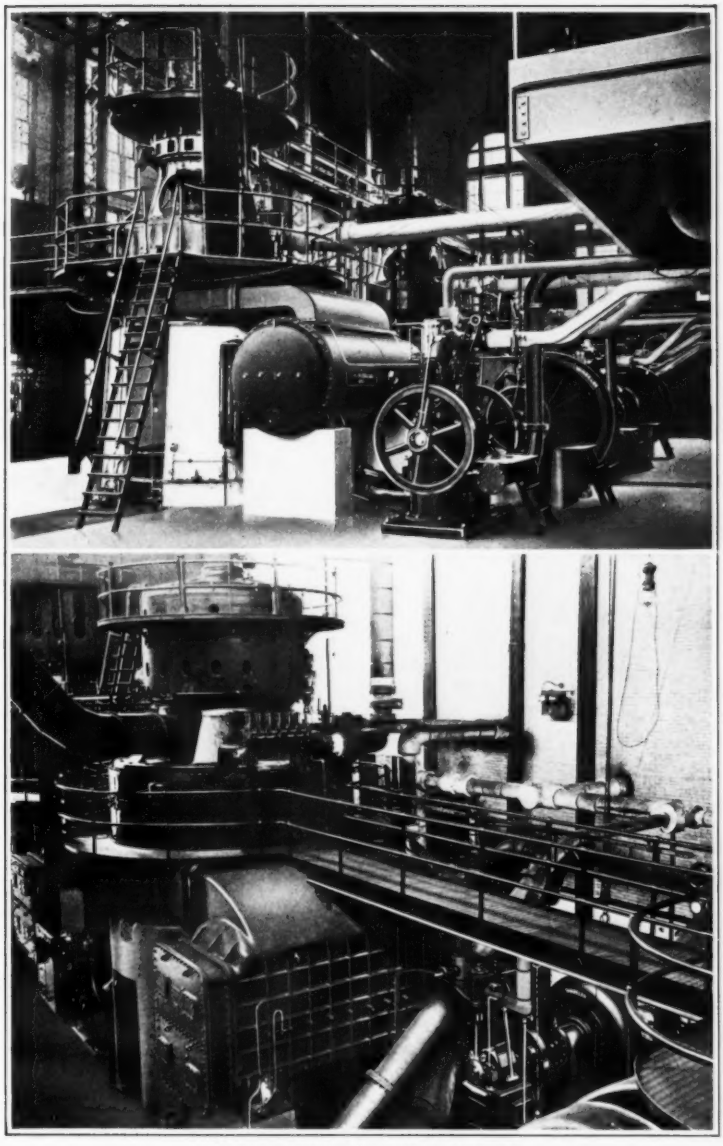


TWIN EJECTOR CONDENSERS, HOLYOKE ELECTRIC LIGHT STATION, FOR 1,000-KILOWATT CURTIS TURBINE.

The Deane Steam Pump Co.

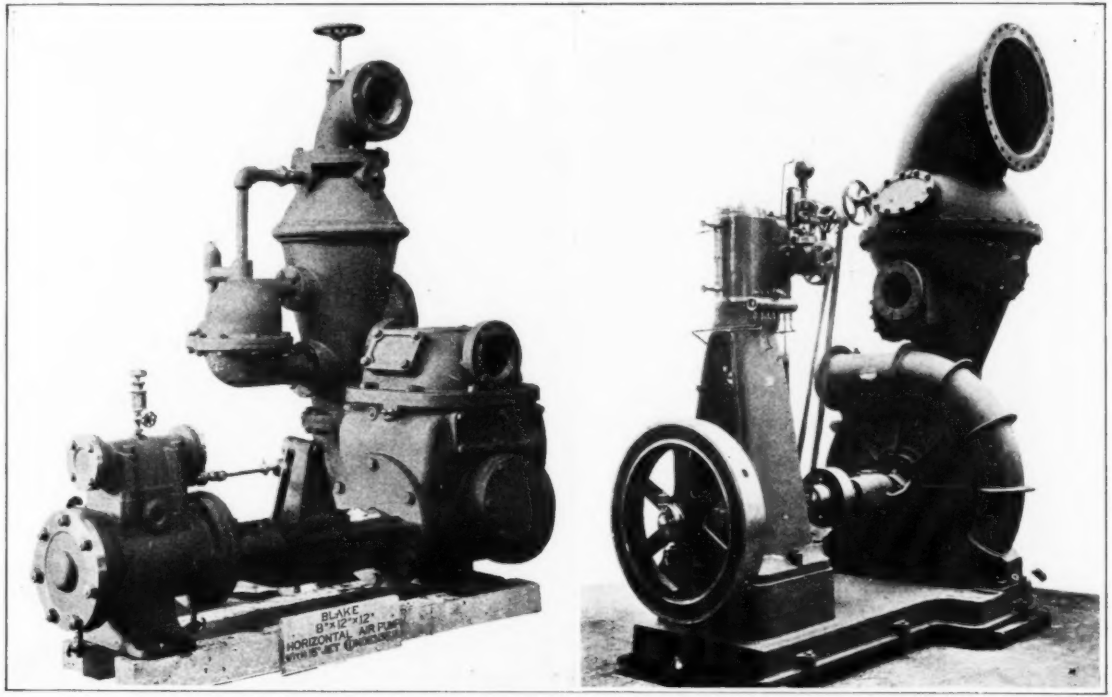
If the connection with the tubes is slightly lower than the barometric height, the pump can be installed anywhere in the system. It can raise the water in one column, whereupon it will flow automatically out of the other, or it can drive the water down in the outflow column with equally satisfactory circulation. Again, the water can be turned in from above, by atmospheric pressure alone, and with its supply regulated by a spray valve, whereupon it will automatically flow out. In this case a barometric column is installed in a well, and the pump must be used simply to lower the water surface in the well, whereupon this will be re-supplied by flow throughout the condenser system. This latter feature of apparent variability in pumping duty explains the remarkable variation in design existing in condenser construction and operation. If an ejector pump is used and operated at a fairly high speed, so as to have an excess capacity over normal supply, it can be used to maintain the vacuum against the atmosphere without the use of a column of water. Hence in the simplest type of the jet condenser, water is allowed to flow naturally through some form of spraying device into a vacuum. This operation is generally accomplished by using the normal atmospheric pressure, but considerable variations in pressure both positive and negative often exists at this point with satisfactory operation. The water then is pumped out from this vacuum chamber as fast as it enters, by means of the ejector pump, and the entire design is very compact and readily attached to small steam units. If the pump is installed as a supply pump on the other side of the condenser system, the outflow occurs automatically through a barometric column, and can be further utilized for partial removal of the air by a device similar to the aspirator, or steam injector. Some types utilize the single pump in the water exhaust, for the removal of the air as well, the air being carried along with the water into the pump cylinder. This, however, results in a very poor efficiency in the actual operation of the pump, as can be readily seen. The air removal is accomplished practically in all condensers of this type, in which a high vacuum must be maintained, by means of a dry vacuum pump, operated as a separate unit. Of course, both the circulating pump and the vacuum pump can be connected with the condenser for condensation of their exhaust steam, and efficiency generally increased, in most installations.

Now the use of the vacuum pump and the spraying device, or rather the immediate contact of steam and water, are responsible for the existence of a number of problems in actual operative



WHEELER CONDENSER INSTALLATIONS.

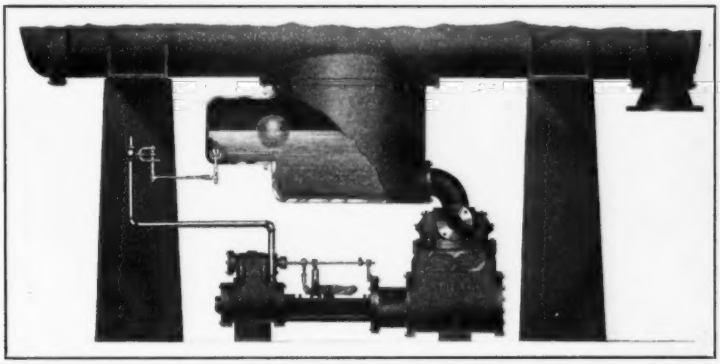
Above, Fall River Electric Light Co.; below, Wheeler surface condensers for Curtis turbines, with engine-driven centrifugal circulating pumps, Public Service Corporaton of New Jersey, Marion, N. J. Wheeler Condenser & Engineering Co.



BLAKE HORIZONTAL JET CONDENSER, AND CENTRIFUGAL JET CONDENSER.

The apparatus on the left represents standard commercial practice for medium-sized reciprocating engines. That on the right is a new design adapted to use with high vacuum for steam-turbine installations; it uses small floor space and avoids long exhaust and water lines. Henry R. Worthington.

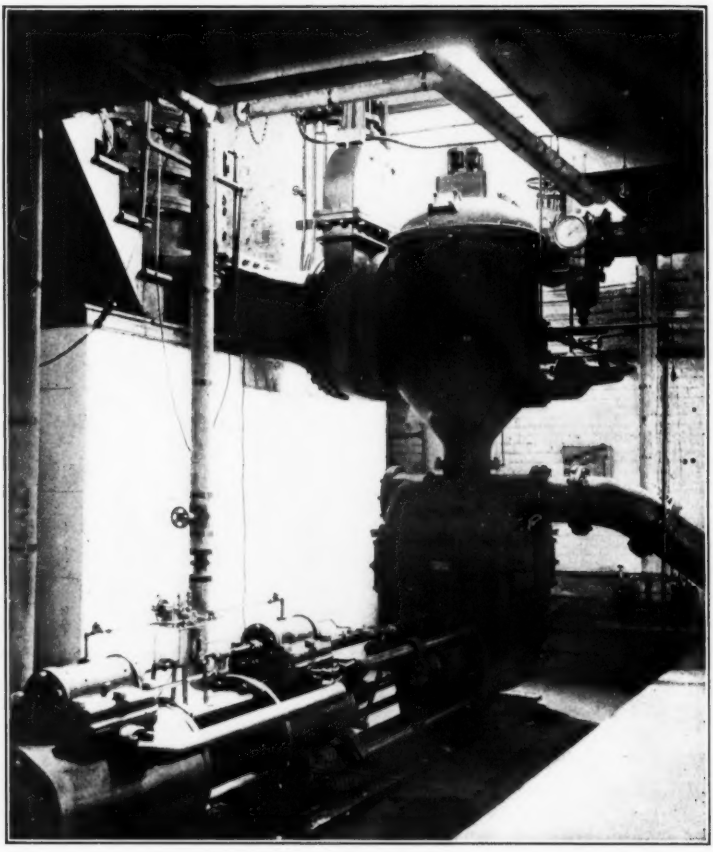
conditions. The water supply must be regulated by a variation in the capacity of the pump, if this latter is of the ejector type, and it must also vary considerably with the steam supply to condensers. If the water supply is not regulated otherwise, and is dependent upon the steam pressure, or pump capacity, it may flow back and flood both the steam engine and the vacuum pump, with disastrous results in both cases. The efficiency of the device is dependent primarily on the maintenance of the vacuum, and if the water becomes too hot, it boils at the reduced pressure, this point often being reduced as low as 150 degrees F.



HORIZONTAL HOT-WELL PUMP.
Wheeler Condenser & Engineering Co.

Interesting devices appear in the various types for the maintenance of the vacuum under all conditions of water circulation and steam load. The Blake and Weiss condensers possess automatic devices for injecting a small quantity of air when boiling of the condenser water occurs. This increase in pressure raises the boiling point of the condenser water and allows the device to operate at a diminished vacuum, which is gradually and automatically increased by the operation of the vacuum pump. The Alberger condensers possess an advantage in regard to the valve regulating the spray, and the design of the condenser head, which permits comparatively dry air to be carried into the vacuum pump.

Various floats and other devices are used in the majority of condensers of this type to prevent flooding. When the water rises in the condenser beyond a certain danger line, a float is lifted and allows air entrance, whereupon the water supply is cut down automatically. Automatic devices or valves exist as well for allowing the steam to be turned into the atmosphere whenever



SINGLE COMPOUND VACUUM PUMP WITH JET CONDENSER, HOLYOKE ELECTRIC LIGHT STATION.

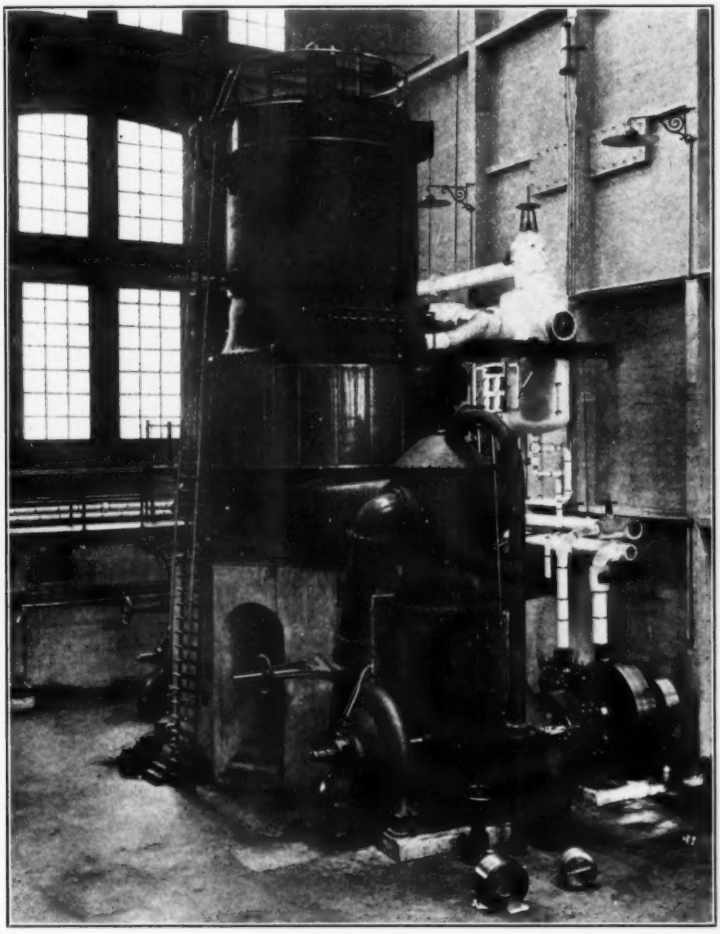
Size 9 by 14 by 20 by 24. Installed by Deane Steam Pump Co.

the condenser ceases to operate. These valves are comparatively simple in construction, since they close against the atmosphere by its pressure, and open naturally when the steam pressure in the interior exceeds this, or bears a certain definite ratio to it.

An interesting problem in ordinary construction of condenser design is connected with the pumping installation for the circulating water. Centrifugal pumps are very unsatisfactory for this work, since their output varies greatly with the pressure. Thus, with an ordinary water supply pump of this type, the amount of

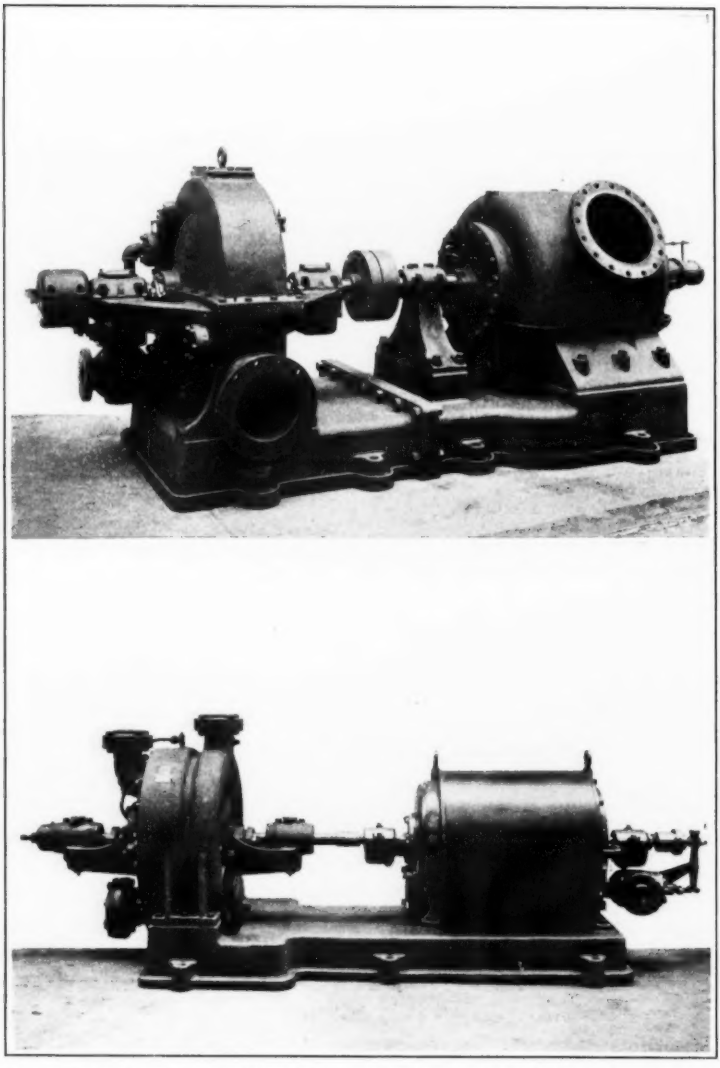
water furnished increases when the vacuum is reduced, whereas for the most efficient operation of the condenser it should diminish proportionally as well as increase in amount when needed.

These problems of water circulation, its variable action under different conditions of temperature and pressure, and the removal of the air efficiently, are further complicated by the necessity of



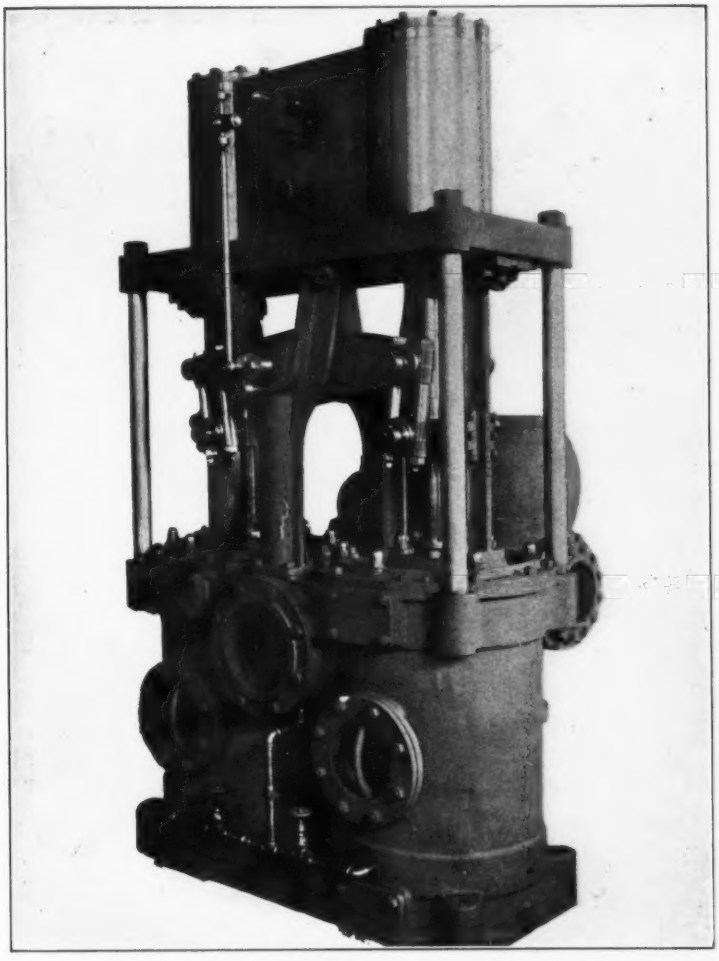
CENTRIFUGAL CONDENSER USED WITH 5,000-KILOWATT CURTIS TURBINE, WESTPORT STATION. CONSOLIDATED GAS & ELECTRIC CO., BALTIMORE, MD.

Alberger Condenser Co.



ABOVE, HIGH-SPEED TURBINE-DRIVEN CENTRIFUGAL PUMP; BELOW, CENTRIFUGAL HOT-WELL PUMP, STEAM TURBINE DRIVEN.

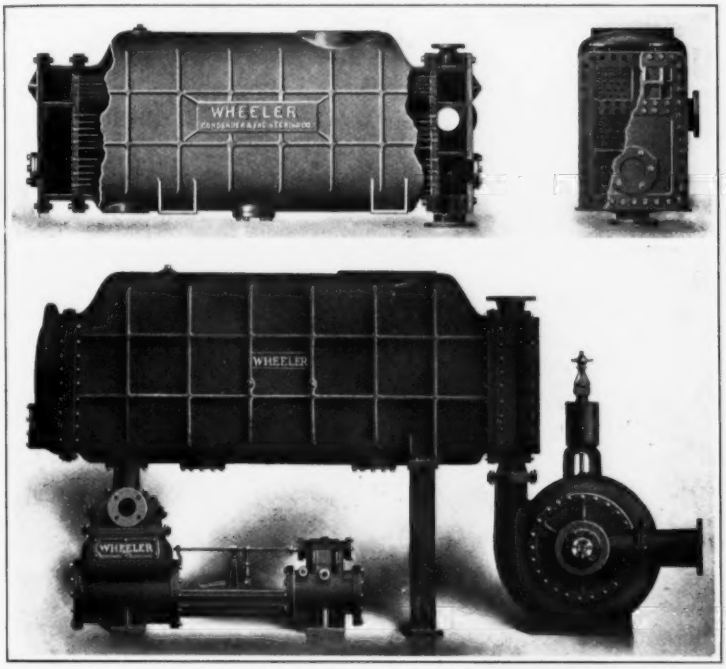
The upper figure is a new form of tri-rotor pump used in very recent installations for circulating water with surface-condenser equipment. The lower is used for taking condensation from surface condensers under high vacuum and delivering into feed-water heaters. Henry R. Worthington.



BLAKE VERTICAL TWIN-BEAM AIR PUMP AND JET CONDENSER.
Widely used in the best power plants and on very many American and other warships.
Henry R. Worthington.

having the condenser operate efficiently under wide variations of steam load. Thus, until quite recently, the variation in steam supply to condensers in rolling mills and similar establishments was such that the action of the condenser was very unreliable in these installations, and in many cases where the horse power in

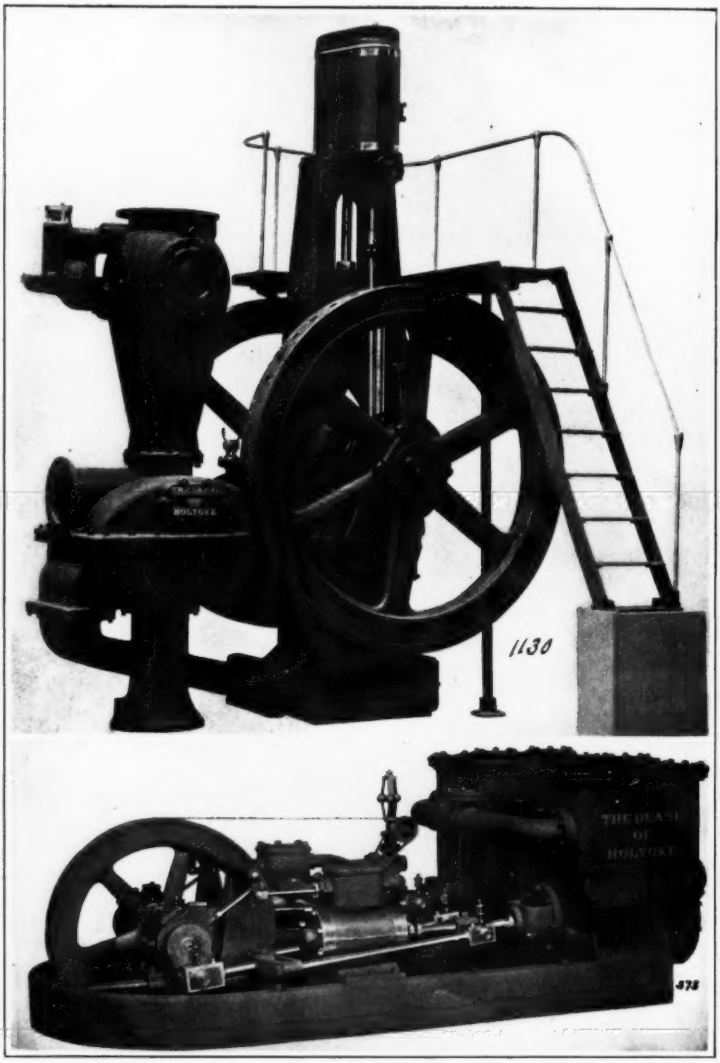
WEISS COUNTER-CURRENT CONDENSER INSTALLATION OPERATING AS A CENTRAL PLANT, BETHLEHEM STEEL COMPANY.
Southwark Foundry & Machine Co.



ABOVE, VOL2 COMBINED SURFACE CONDENSER AND FEED-WATER HEATER. SECTIONAL VIEW; BELOW, WHEELER ADMIRALTY SURFACE CONDENSER WITH DIRECT-ACTING AIR PUMP AND CENTRIFUGAL CIRCULATING PUMP.

Wheeler Condenser & Engineering Co.

the mill was rated on condenser conditions and used at its maximum, the engines were compelled to shut down temporarily in case of the non-operation of the condenser. Condenser design and installation is therefore as much a special problem for individual cases as for general types. The use of large central condensing installations of condensing capabilities sufficient to take care of the steam from engines aggregating as much as 24,000 horse power, is not uncommon. By combinations such as these, the variability of load has been much reduced, the efficiency of operation greatly increased, and water supply can be more readily regulated. Advantage lies with the larger single pumping units in place of several small ones. On the other hand, such central plants are more or less difficult to install under conditions such as are met with in ship design, and various local conditions often affect their applicability to other departments.



SINGLE VERTICAL FLYWHEEL VACUUM PUMP WITH CONDENSER, AND DUPLEX FLYWHEEL VACUUM PUMP.

Both by Deane Steam Pump Co. The vertical pump is 12 by 24 by 18, and the horizontal duplex is 10 by 14 by 12.

RECENT DEVELOPMENTS IN CONVEYING MACHINERY FOR COAL AND ASHES.

By Wilbur G. Hudson.

The systematic discussion of both mechanical features and cost-saving of coal-handling machinery conducted by Mr. Hudson greatly exceeds the space available for a single article. The remainder of his study will appear in our August issue and will cover reserve storage, pivoted bucket carriers, screw conveyors, skip hoists, coal-weighing devices and specialized ashes-handling machinery.—THE EDITORS.

DEVELOPMENTS of conveying machinery for coal and ashes in the last few years have been marked, covering roughly the transition from a chain of scrapers, dragged noisily along a trough, to the modern suspended-flight conveyors, carriers, and belt conveyors doing their work silently and efficiently. More attention is paid to the details affecting economy in operation; note, for example, the substitution of rolling for sliding friction in the modern "roller-flight conveyor" of Figure 1. The rollers are made hollow and packed with absorbent material. There is a clearance of ¼ inch between flight and trough, making the operation of this simple type of "scraper conveyor" noiseless and fairly efficient. There has been a notable improvement in conveyor chains. The older, heavy malleable and wrought-iron links are widely supplanted by the lighter and stronger bushed chains with drop-forged steel links. Strength, however, is not the only requirement. Unless the articulation of the links provides for ample bearing surface and thorough lubrication, there will be rapid wear, variation in pitch, and bad action at the sprockets. Large bearing surface but defective provision for lubrication, is, on the whole, worse than insufficient bearing surface, accompanied by open joints kept well lubricated.

An example of the refinement of design in conveyor chain is the "Maximum chain" developed from the old "two and two" steel chains in which the links were made up of steel flats with soft-steel pins rivetted over. This was very powerful in proportion to its weight, but its strength was out of all proportion to its bearing area at the joints. The engineers of the Pennsylvania anthracite region improved it in what is sometimes called the "Lehigh Valley" chain, which has drop-forged links with thickened ends to secure more bearing area and better distribution of metal. The bearing surfaces were still inadequate, and there was difficulty in using hardened pins because of their

FIG. 1. WEBSTER ROLLER FLIGHT CONVEYOR, DELAWARE AVENUE POWER PLANT OF PHILADELPHIA RAPID TRANSIT RAILWAY.

ends having to be rivetted over. The Maximum chain cleverly overcomes these defects as shown in Figure 2. The links are high-carbon drop-forged steel, the pins are hardened, and the lugs on the links make the bearing area the whole length of the pin. The joints are packed with graphite grease in assembling. Figure 3 shows the appearance of the assembled chain. The particular inclined conveyor illustrated is about 300 feet centers with a capacity of 250 tons per hour. I dismantled several of these links after 80,000 tons of coal had been handled, and found them in fine condition, with the bearing surfaces merely brightly polished, and no perceptible wear.

Coal-Conveying Machinery.

For large capacities, say more than 100,000 tons annually, the cost of power and maintenance in any coal-handling installation is considerable. Certainty of operation and economy of space are factors requiring attention. When coal is handled in the enormous quantities and under the conditions existing in blast-furnace practice, coke plants, and collieries, the most important consideration, taking precedence over all others, is reliability. Even the temporary disablement of the conveying machinery is a catastrophe usually involving considerable expense, if not entailing the complete shut-down of the plant. Often in such cases the conveying system is in duplicate, so that ordinary repairs may be made without interrupting the service. Reliability, then, is most important; but since the tonnage is so large, the repair and maintenance charges per ton handled are worthy of serious consideration in determining the design.

Belt Conveyors.—Belt conveyors are well adapted to large tonnages. The high belt speeds practicable give a very large rate of handling with comparatively small width of belt. The improvements

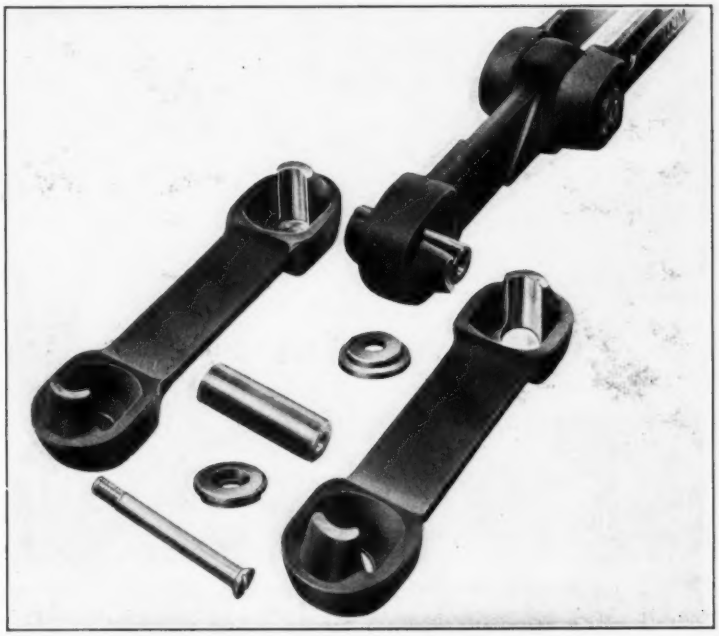


FIG. 2. THE LINK BELT COMPANY'S "MAXIMUM" CHAIN.

in supporting idlers have aided in reducing the power required for operation and contributed to the life of the most expensive part of the conveyor—the belt. Of more importance, the belt itself has been brought to a state of perfection where its uniformity and resistance to abrasion are remarkable. The latest designs of carrying idlers vary. Some manufacturers favor a unit made up of four or even five short idlers (Figure 4) with their upper edges approximately a catenary, while others advocate the single roller, flared at the ends to give the desired troughing effect. The former is criticised as regards

FIG. 3. SUSPENDED FLIGHT CONVEYOR EQUIPPED WITH "MAXIMUM" CHAIN.

Rope drive extends along the truss to the head end. A "depressor" or guide chain is used at the bend of the conveyor instead of a sprocket wheel, to eliminate churning and breaking of coal.

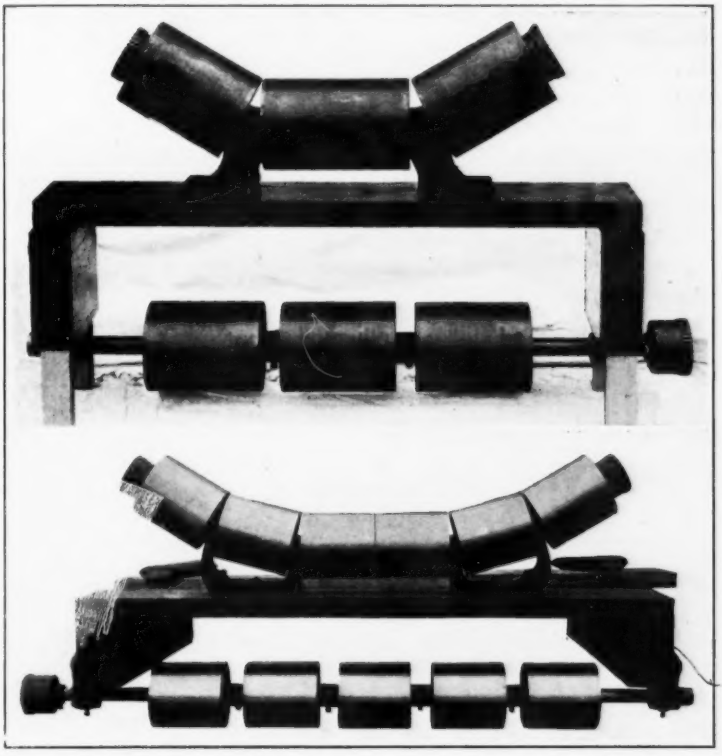


FIG. 4. MULTIPLE TROUGHING AND RETURN-IDLERS FOR BELT CONVEYORS.
Robins Conveying Belt Company.

lubrication. Oil will be thrown on the belt from the central bearings, or if grease is used there is an increase in friction and more or less difficulty from "frozen" idlers. The latter design is ideal as regards lubrication, especially as brought out with pivoted chain oiling bearings and light spun steel rolls (Figure 5). It is open to the criticism that there is an unavoidable slip between belt and rolls, owing to the flaring ends. However, conveyor belts in active service wear out on the carrying face, not on the underside, and the structure of the belt itself rather than the design of idler is the vital point, except that the idler must not be too deeply troughed, as this has a bad effect on the protecting rubber covering. The earlier belts gave trouble through the rubber stripping from the fabric and from tendency to crack along the carrying surface. The best conveyor belts today have not these

defects. The carrying surface is formed by a vulcanized layer of nearly pure high-grade rubber. The chief source of wear is the impact and abrasion of the material handled. This effect is a maximum along the center of the carrying surface and decreases to zero at the edges. The best design of belt will therefore have its protecting covering thickest at the center, decreasing uniformly toward the edges. The belt should be uniform in thickness and stiffened at the edges to resist the action of the side guide idlers and and reduce the lateral bending between carrying idlers.

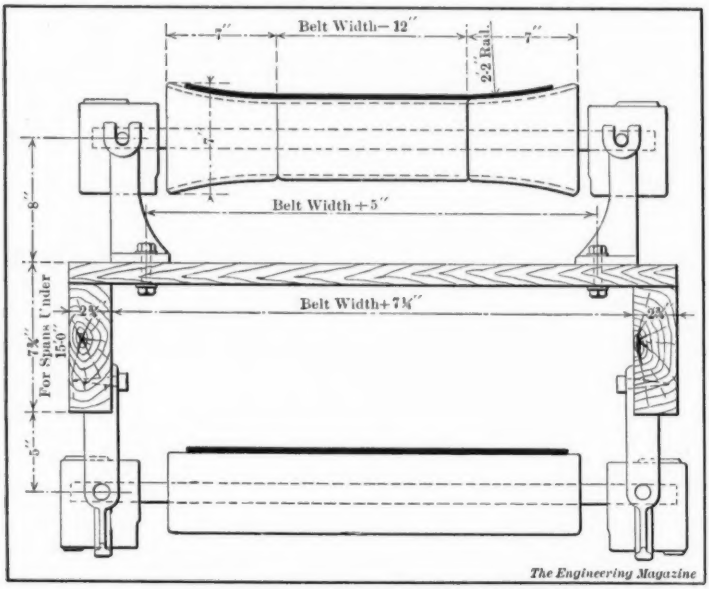


FIG. 5. SHALLOW TROUGH SPUN-STEEL BELT-CONVEYOR IDLER WITH EXTERNAL RING OILING BEARINGS. LINK BELT ENGINEERING CO.

Figure 6 is a half section of the belt made by the Robins Company, who have given considerable attention to this important matter. The edges are stiffened by doubling back the fabric. The armor thickens toward the center, insuring the longest possible life, for when this covering is finally destroyed a belt will rapidly fail.

Belt conveyors, whenever possible, should be loaded by directing the flow of material in the direction in which the belt is moving, to reduce impact and abrasion. Placing a screen at the lip of the chute is of some benefit, the fine material making a cushion, though the screen is apt to clog up and become ineffective.

RIGID BUCKET CARRIERS.—The belt conveyor attains its great capacity with a narrow stream of coal moving at high speed. The converse of this—large mass at slow speed—was characteristic of the powerful scraper conveyors so widely employed for heavy service, but which are now gradually being superceded by "rigid bucket carriers," composed of steel overlapping buckets secured to two runs of heavy roller chain. These are practically immune from breakdown if properly designed, and while their first cost is high, their long life and low maintenance charge assure a handsome return on the greater investment. They are supplanting the large scraper conveyors used in transferring coal from shaft to breaker in the anthracite districts of Pennsylvania, where a breakdown involves considerable loss.

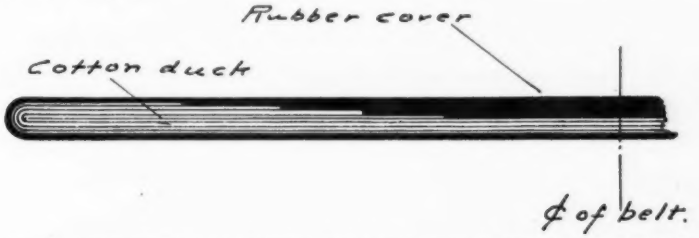


FIG. 6. CONVEYOR BELT OF UNIFORM THICKNESS WITH RUBBER COVER THICKENED TOWARD CENTER AND EDGES STIFFENED BY DOUBLING BACK THE PLIES.

Probably the most severe conditions that coal-handling machinery is called upon to withstand are met throughout this region. There has been a marked evolution in the quality of all machinery installed there recently, coincident with the consolidation of interests. The engineers have unusual facilities for testing out weaknesses of design as their operations become more extensive. The average conveyor designed for, say, 300 tons per hour, usually has an opportunity to show what it can do with double that load before it is long in service.

The location of the breaker of an anthracite mine, with reference to the head of the shaft, very often calls for a main conveyor to elevate the run-of-mine coal. The whole system is dependent upon this conveyor, and it must be absolutely reliable. The heavy two-strand suspended-flight scraper conveyor, with flights as large as 12 by 50 inches, proved excellent in this service. The trough upon which comes the heaviest work was frequently made up of ½-inch cast iron "chute plates" to resist the continual abrasion of the coal, and the driving machinery, shafting, and chains were all exceptionally heavy. The capacity ran from 1,200 to 2,500 tons per day of 10 hours. Larger capacities were called for in recent operations,

resulting in the introduction of these rigid bucket carriers, with capacities exceeding 4,000 tons in 10 hours, and with decreased frictional losses and maintenance costs, and better provision for replacement of worn-out parts. The first of these to be installed was at No. 14 breaker of the Pennsylvania Coal Company near Pittston. (See Figure 7). It is 355 feet centers, on an incline of 25 degrees. The two bushed steel chains are of 24-inch pitch with side bars formed of 5 by ½-inch flats. The pins are 2 inches in diameter, with collars which engage the driving sprockets. The speed is 120 feet per minute. Figure 8 shows the carrier under light load. When handling 500 tons per hour, the buckets are completely hidden under the mass of coal. The machine was started in 1902 and handles about 130,000 tons per month. When I last inspected it, after 3 years' service, it was still in excellent condition. The cost of repairs had averaged four one-hundredths of a cent per ton handled for material and six one-hundredths of a cent for labor, or a total repair cost of one-tenth of a cent per ton. A number of breakers have since been similarly equipped.

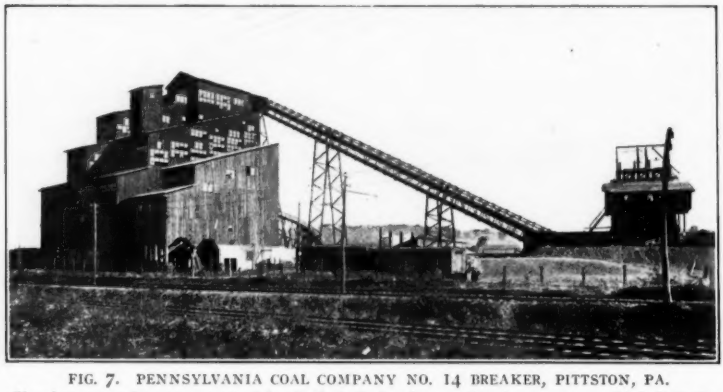


FIG. 7. PENNSYLVANIA COAL COMPANY NO. 14 BREAKER, PITTSTON, PA.
Showing general arrangement of head of shaft, breaker, and main conveyor. Link Belt Co.

The advantages in this type of machine are obviously those of rugged construction and slow speed. The parts subjected to wear are easily removable. The older scraper lines were also rugged and durable, but considerably less efficient as regards power consumption and breakage of coal. In No. 14 breaker carrier the apron after handling over 2,000,000 tons of coal was practically in the same condition as when new. The teeth of the driving sprockets are faced with removable steel wearing plates and engage with rollers mounted upon the bushings of the chain, and showed very little wear. There

FIG. 8. NO. 14 BREAKER CONVEYOR HANDLING LIGHT LOAD.

is very little liability of serious breakdown. The driving pinion is not keyed to its shaft, but secured by a steel breaking pin of such cross section that an overload or obstruction instantly snaps it, and the carrier comes to rest.

MARYLAND STEEL COMPANY'S COAL-HANDLING EQUIPMENT.—An interesting example of coal handling in large capacities is exhibited by the equipment of the Otto coke plant of the Maryland Steel Company, which has been very successful in its operation.

Coal is delivered from four track hoppers, equipped with automatic feeders, to two double-strand monobar scraper lines, 117 feet centers, with suspended flights every 3 feet. These conveyors deliver the coal to two disintegrators, and the product is elevated by two gravity discharge elevators, with 24 by 12 by 42-inch buckets spaced 3 feet apart. These discharge upon a 30-inch belt conveyor running horizontally 253 feet to the storage bins.

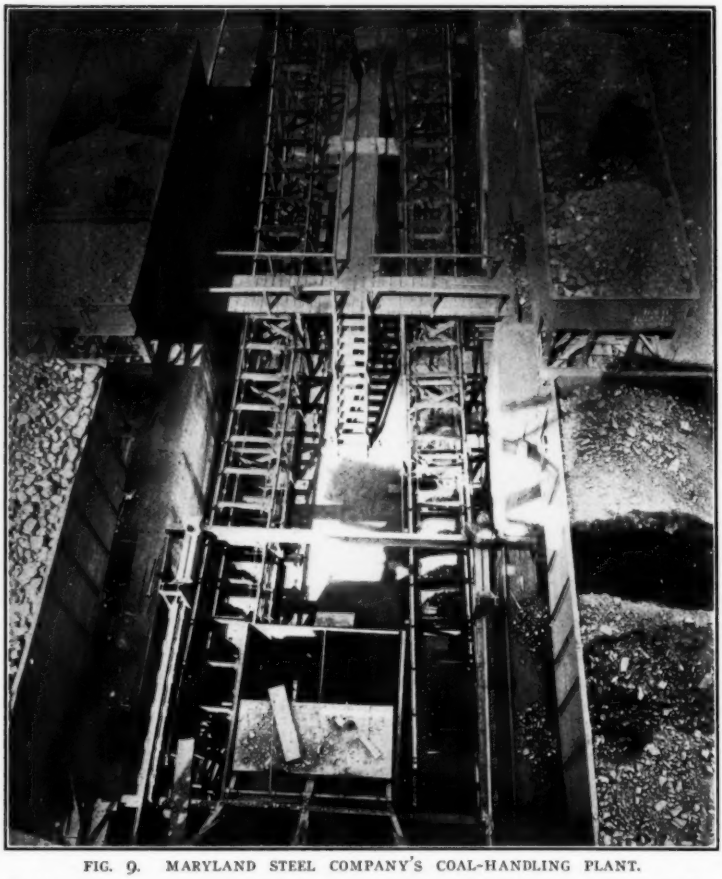


FIG. 9. MARYLAND STEEL COMPANY'S COAL-HANDLING PLANT.
Looking down from pivot end of bridge tramway toward two Monobar conveyors leading to the disintegrators. Link Belt Company.

A pivoted bridge tramway with a 2-ton electrically operated grab bucket is tributary to the system and provides a reserve storage of 50,000 tons. Figure 10 is a general view of the plant. To the left is the pivot end of the bridge in course of erection. The arrangement of the two elevators is shown clearly, extending up to the belt conveyor bridge along which the coal is carried across the service bins of both batteries of coke ovens. Figure 9 was taken from the tramway looking directly downward upon the flight conveyors. Four 50-ton cars are seen discharging into them.

In the foreground is the chute leading from the tramway hopper to the conveyor feeders, in position to receive coal from the storage pile. The capacity of this installation, with all the machinery in operation, is 220 tons per hour, or holding one elevator, crusher and feeding conveyor in reserve, 110 tons per hour. The machinery has been running almost continuously since March, 1903, at an average of 70 hours per week. The daily tonnage is 1,200.

FIG. 10. COAL-HANDLING SYSTEM, MARYLAND STEEL COMPANY, SPARROW'S POINT, MD.

The total cost of repairs in material and labor averages four-tenths to five-tenths of a cent per ton handled, and the labor cost of operating about nine-tenths of a cent per ton. The installation has been handled with intelligence and care, and to this without doubt much of the credit for its excellent record is due. Power readings at the motor are as follows:

Machine.	Starting Motor.	Load.	Empty.	Loaded.
	All figures in horse power.			
Each Feeding Conveyor 117 Feet Centers: 30 feet rise, 10 by 42 inch suspended flights spaced 3 feet. Speed 105 feet per minute	25	20	5.8	12
Each Pair of Automatic Feeders: Each plate 3 feet 6 inches wide by 11 feet long, stroke 6 inches	5	5	3	5½
Each Crusher: Two rolls 47 inches diameter by 36 inches long	50	43	8	12—17
Each Elevator: 94 feet vertical lift, 16 feet horizontal run, V-buckets 24 by 12 by 42 inches spaced 3 feet apart; speed 105 feet per minute	40	27	8	18
Belt Conveyor 253 Feet Center: 30-inch belt; speed 650 feet per minute.	25	24.3	11	12

Moving tripper with belt empty runs up power of belt conveyor to 14 horse power.

When the test was made, coal was being handled at the rate of 215 tons per hour, *i. e.*, 107½ tons to each feeding conveyor, crusher, and elevator, and 215 tons per hour upon the belt. The life of the belt handling crushed coal is 18 months. The ¼-inch steel troughs for the monobar conveyors are good for about 20 or 22 months. An occasional flight must be replaced. The knuckles of the chain are of very ample wearing surface and of long life. The elevator is of unusually heavy construction, with hardened chain pins and chilled driving rollers. The rate of wear here is very slight except at the pinions of the motor and countershaft. The brunt of the work comes upon the disintegrators whose business it is to reduce run-of-mine bituminous to 1 inch and under, and although their digestion is excellent, a stray car coupler or similar diet sometimes lays one or the other up for repairs.

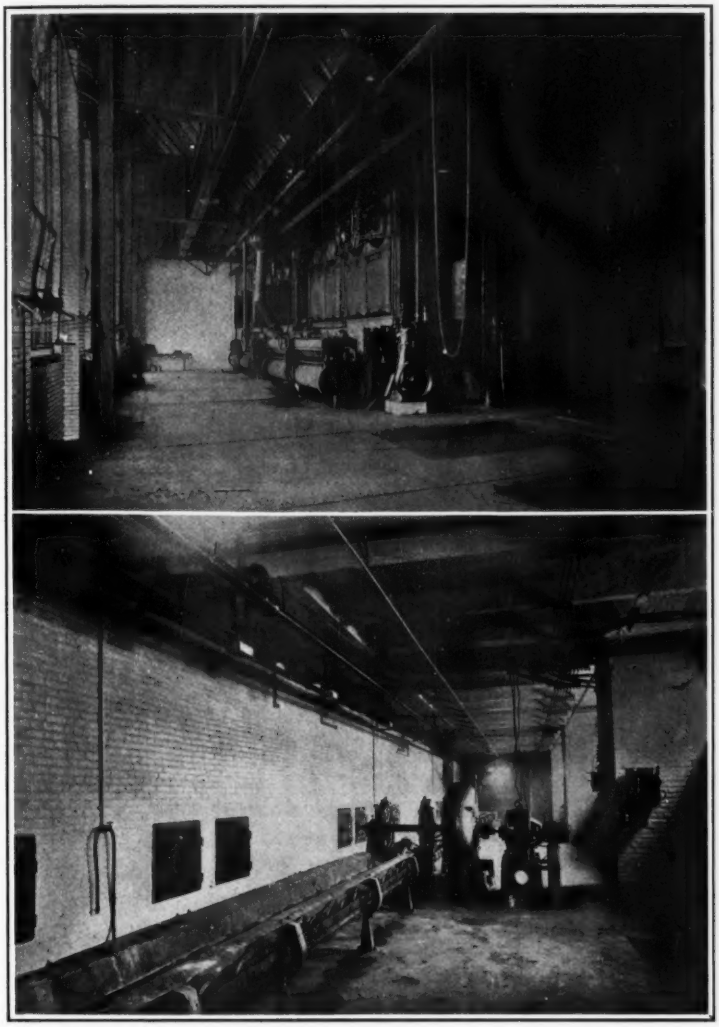
The coal-handling installation at the new coke plant of the Consolidated Gas Company at Astoria, N. Y., is quite similar to this, embodying improvements in design suggested by it, and is an excellent example of good practice in machinery of this type.

Boiler-Plant Coal-Handling.

The foregoing are instances of heavy service and tonnage. The average engineer is more interested in the broader field of boiler-house coal-handling machinery. Here the conditions are somewhat different. Uninterrupted service, while important, is less so. The tonnage is less, and more attention is usually paid to costs of handling. Usually there is either sufficient reserve capacity in the bunkers to permit ordinary repairs without embarrassment, or such emergency is otherwise provided for.

The problem of economically handling coal from cars to furnaces in the modern boiler plant is receiving considerably more attention than hitherto, as the expense of obsolete methods is now generally appreciated. Shoveling coal over the sides of hopper bottom cars, wheeling it to a stock pile, and finally to the boiler room to be shoveled into furnaces, involves a handling cost of from 25 cents to 45 cents per ton, which may be reduced by 80 per cent where the introduction of up-to-date methods is practicable. With the conditions usually encountered, the requirements are ordinarily an overhead storage bunker, with suitable elevating and conveying machinery, supplemented when convenient by an outside or reserve storage.

Storage Bunkers.—Bunker design is an art in itself. It is a rather curious fact in my experience that the architect usually leans toward a built-up or framed steel bunker, while the contracting engineers specializing in this line of work prefer the suspension type.



HUNT COAL AND ASHES-HANDLING MACHINERY, CLEVELAND TWIST DRILL COMPANY.

Fuel is received in dump-bottom cars, passed through a crusher into a bucket-type conveyor, and delivered by a movable tripper into bunkers holding a month's supply, 500 tons. The same conveyor carries ashes from ashpits to an ash bunker. C. W. Hunt Co.

Possibly the lower cost of the latter with the corresponding advantages in competitive bidding has something to do with this, but as a general proposition, the adaptability of the suspended bunker to existing conditions, its large coal capacity per pound of material with resulting economy of space, give it a decided advantage. Coal bunkers should be lined with concrete. The life of a steel-plate bin is fixed by the rate of corrosion brought about by moisture and sulphurous acid from the coal. It may be said that a steel-plate bunker should have the thickness of the plates increased above what is required by the mere considerations of strength, to an amount based upon the desired life of the bin with relation to the probable rate of corrosion. Several steel-plate bunkers erected between 1900 and 1902 recently inspected were found seriously corroded after 6 or 8-years use, particularly at the seams and rivets. The firm with which I am connected has had excellent results with the ferro-inclave, cement lined, suspended type bunker shown in Figure 11.

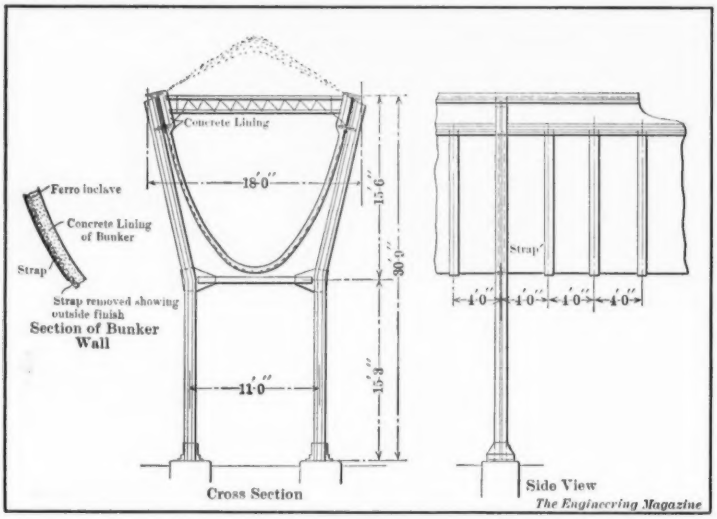


FIG. 11. FERRO-INCLAVE SUSPENSION BUNKER.

Ferro-inclave is manufactured by the Brown Hoisting Machinery Company and is a patented corrugated steel sheet formed by special dies which give dove-tail corrugations. The frame of a ferro-inclave suspension bunker is made up of steel straps about ⅜ inch by 8 inches in section, spaced about 4 feet centers and suspended between two longitudinal girders, so as to give the required parabolic curve.

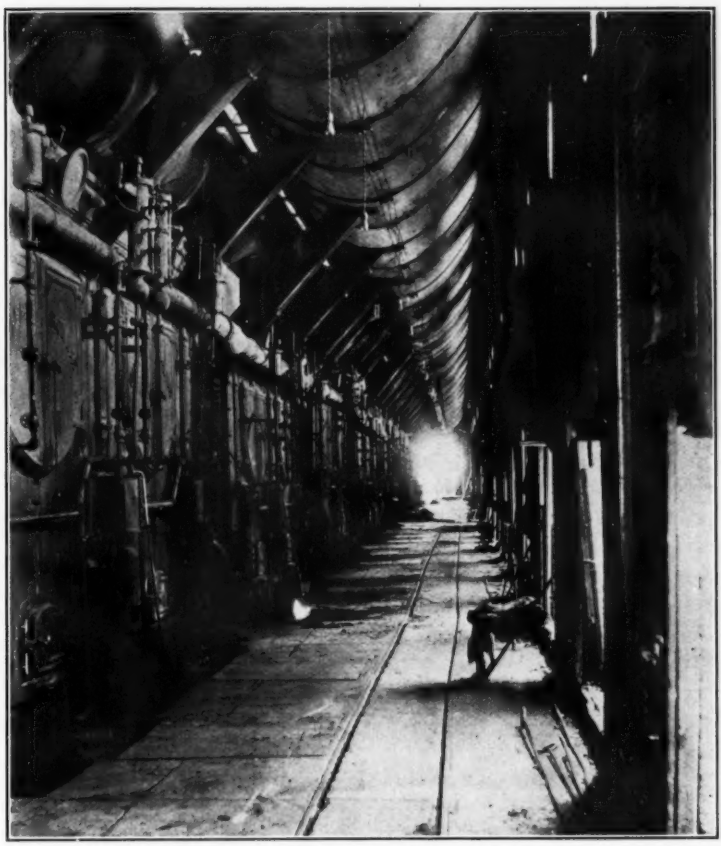
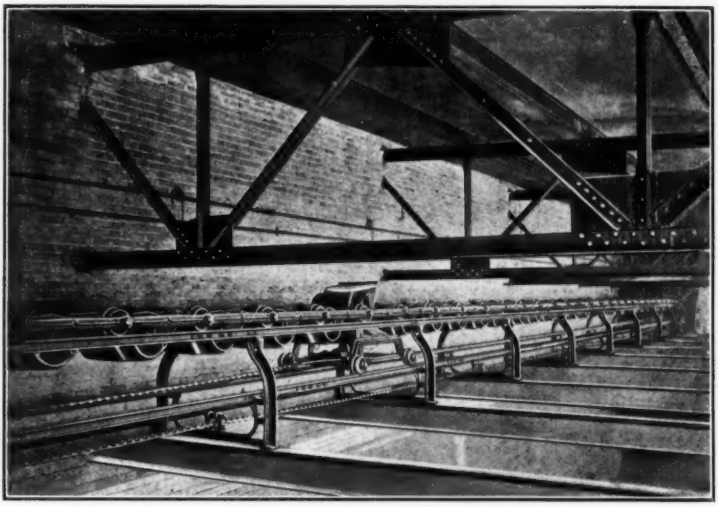


FIG. 12. FERRO-INCLAVE SUSPENSION BUNKERS, WORCESTER SALT COMPANY.

On the steel straps sheets of ferro-inclave are laid, and the outline being preserved by suitable forms, a lining varying from 3½ inches to 1 inch thickness of rich cement mortar is applied. The outside of the ferro-inclave is similarly plastered with a ½-inch protecting covering. This gives a storage bunker that is very efficient, remarkably neat in appearance, and of many times the life of a steel bunker. The lining may readily be made waterproof if desired.

Figure 12 shows the suspension bunker of the coal-handling system installed by the Guarantee Construction Company for the Worcester Salt Company's plant at Silver Springs, N. Y. The bunker is 300 feet long with spouts leading directly to the Murphy stokers of



UPPER LINE OF M'CASLIN OVERLAPPING GRAVITY BUCKET CONVEYOR.
Mead Morrison Mfg. Co.

the boilers. The whitened outside face of the ferro-inclave sheathing adds considerably to the light, cheerful appearance of the boiler room. Incidentally, this installation is an interesting example of the saving which may be effected by an alert management by the introduction of suitable labor-saving machinery. This plant in its unimproved state did not differ materially from the common old-fashioned arrangement of a low, outside railway trestle under which coal was stored, then wheeled and shovelled into the boilers by the usual regiment of firemen. Fifty thousand tons of coal are burned annually, and the up-to-date coal-handling system, consisting of a standard arrangement of track hopper, feeder, crusher, conveying machinery, overhead storage bunker and stokers, has already led to a saving in labor of $1,000 per month, or 24 cents on every ton of coal handled. The fire-room staff has not yet been cut down to meet entirely the present conditions, so a still further saving will finally be accomplished.

Instead of leading the spouts directly to the stokers, undercut gates may be provided for discharge into one or more movable weighing hoppers suspended from a track directly beneath the bunker. This gives a convenient check on the amount of coal burned for any period, and is a convenience also in drawing coal from any portion of the bunker for boilers beneath an empty section.

THE STEAM TURBINE AND THE RECIPROCATING ENGINE FOR MARINE PROPULSION.

By Ira N. Hollis.

In two preceding articles, published in our April and May issues, Prof. Hollis reviewed the history of the design, manufacture and installation of the low-pressure steam turbine, and discussed its economic importance as an adjunct to reciprocating engines in stationary steam plants. This second phase of his argument is broadened to include generally the entire question (most interesting at present) of the turbine in marine service, either in competition or in combination with engines of the older type. The present installment is concerned with examples and a concluding portion next month will formulate deductions.—THE EDITORS.

THE use of steam for marine propulsion has grown by a series of rapid advances followed by long seasons of slow development in the perfection of details. The successive stages have been the paddle wheel with the simple reciprocating engine; then, the screw propeller with the simple engine, the compound and multiple-expansion engines, and, finally, the steam turbine. Ocean speeds have steadily increased as the weight of machinery and the consumption of coal per horse power have been reduced. The impracticability of maintaining high speed with simple engines was demonstrated in the pioneer of the ocean greyhounds forty-four years ago, in the steam trial of the Wampanoag. She was originally designed to run down commerce destroyers like the Alabama, and for that purpose she had great speed under steam and in addition full sail power for keeping the sea without recoaling. Her hull was entirely of wood. The main engines were geared to the propeller shaft in a ratio of 1 to 2.04 by means of enormous wood-toothed spur wheels. There were two horizontal engines with cranks at right angles and cylinder 100 inches in diameter by 48 inches stroke. The steam pressure was 32 pounds. Although it is doubtful if the ship could have been used for extended cruising, on account of the combination of great weight of machinery with a wooden hull, nevertheless she made a record speed for ocean craft which was twenty years in advance of her time. On a trial trip lasting 37½ hours, she averaged 16.71 knots an hour, reaching during one hour the unparalleled speed of 17.75 knots. There was much controversy over the ship, but there is little doubt of the racking effect of the machinery and

the general behavior of the gear wheels, which are said to have worn excessively. Still, the design and construction of such a ship was a great achievement and the use of gearing was the only correct solution of high speed with a wooden hull and a screw propeller. She was taken to the Navy Yard at New York as unsuitable for cruising and there rotted away.

The improvement in materials and the increase of piston speed made possible in iron hulls gradually reduced the weight of machinery per horse power and brought into existence the well known triple-expansion engine which has become a standard type. One of the most interesting exhibits at the Engineering Congress at the World's Fair in 1893 was a drawing of the Powhatan's engines alongside of one showing the latest designed engines for a torpedo boat. They were both to the same scale, and the change wrought in forty years was strikingly shown at a glance. The relative weights of machinery, including engines, boilers, water, and everything chargeable to propulsion under steam, was 972 pounds per horse power for the Powhatan and 56 pounds per horse power for the torpedo boat. The latter does not represent the weight of machinery chargeable to propulsion for large war vessels or merchant ships which are expected to make long voyages in our day. It is from 200 to 400 pounds per horse power, depending much upon the amount of forced draught used in the production of steam.

The steam turbine, dating back only fifteen years, is now rapidly taking the place of the triple-expansion engine for many classes of ships. Perhaps the most interesting phase of ocean navigation today relates to the struggle between the highly perfected triple- and quadruple-expansion engine and the steam turbine. Each seems to be occupying a definite field, the latter for war vessels and high-speed merchant ships, and the former for all kinds of moderate-speed craft.

The multiple-expansion engine has been designed for all horse powers up to nineteen-thousand in one unit—and for all sizes of vessels. It represents the progress of one century in steam navigation. Its ready adaptation to twin screws had made it practically universal for the Atlantic service, and a reasonably high piston speed together with great range of expansion had reduced the coal consumption to a minimum for long voyages. Nevertheless, it had reached its practical limit as to size and economic performance under existing design when the two great turbine ships of the Cunard Company were built. In making a comparison between the two machines, however, it is well to remember that the multiple-expansion marine engine has not kept pace with the best stationary practice in

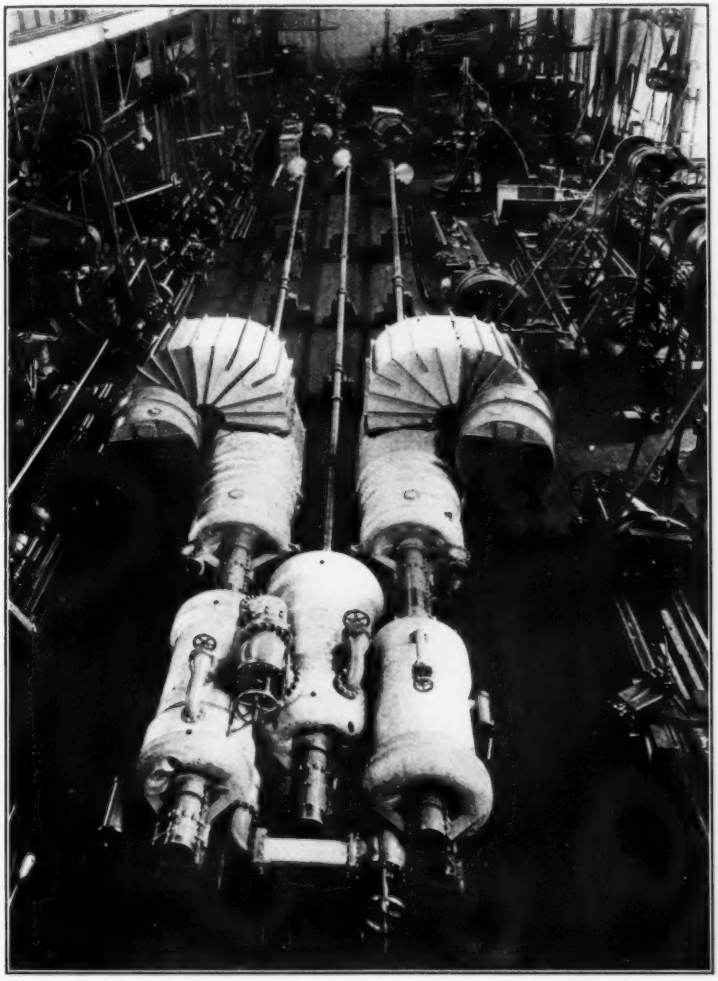
regard to economy. There is still room for gain, and the steam engines which the turbine is replacing may develop unexpected qualities under sharp competition.

The modern reciprocating engine for marine purposes has been standardized into two types: 1, three-cylinder triple-expansion engines for moderate piston speeds and low power; 2, four-cylinder triple-expansion engines for high piston speed and large power. Both types usually have piston valves on the high and intermediate cylinders, with double-ported slide valves on the low-pressure cylinder. Common practice is tending toward slide valves for the intermediate cylinders, especially for small powers. In all the cylinders the stroke is relatively short and the percentage of clearance is large; so that the economy is not what might be attained with gridiron or Corliss valves. While engineers have very generally agreed upon the mechanical parts of these engines, there is nothing like the same consensus of opinion on the steam jacket. Its use is of very doubtful benefit for marine purposes, although it has not by any means been given up, especially for cruising ships. The difficulty in the case lies in the abnormal shape of the cylinders, which are relatively short in comparison with the diameter. Thus, with the ordinary design of engines, the jacket is questionable; under the actual conditions of running the operation of the jacket is seldom satisfactory. It is often too poorly drained to be effective and the complication required to keep it in efficient working order is a trial to the engineer. Superheated steam is rare, although in some cases it has been successfully used, particularly where the superheat is moderate. Inasmuch as the cylinder must be oiled for steam of high temperature to prevent cutting, it is doubtful if the gain would be worth the complication necessary. Oil is a breeder of trouble to the ordinary Scotch boiler, and engineers have practically dispensed with it on all internal surfaces of vertical engines; therefore, high temperature is dangerous. It is said that superheated steam can be used with a small amount of graphite in the cylinders and periodical wiping with vaseline. One of the possible improvements in the marine engine would be the use of reheaters in the receivers and the wonder is that they have not been fully tested. A small amount of superheat so that the steam might reach the high-pressure cylinder perfectly dry, followed by enough reheating in the receivers to send superheated heat into the intermediate and low-pressure cylinders, ought to yield a very sensible gain. The drains could be sent back to the boilers by pumps.

The steam pressure has gradually mounted to something over 200 pounds per square inch for quadruple-expansion engines, but it

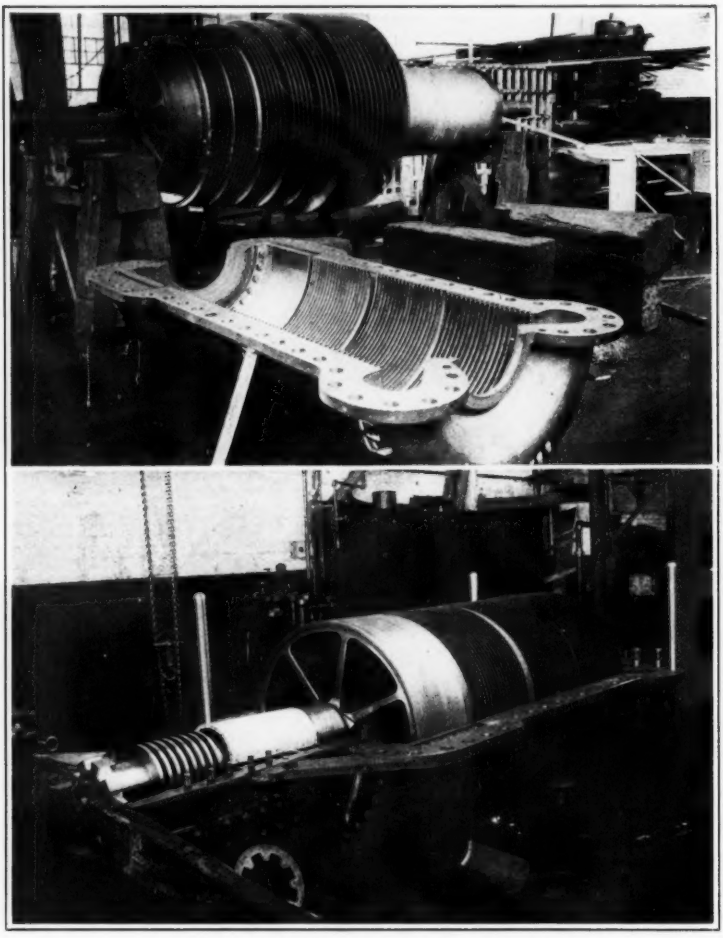
would be difficult to state exactly the gain. It is not even possible to state the advantage of the quadruple- over the triple-expansion engine. When the large size of the additional cylinder needed to get the benefit of great range of expansion is considered and the consequent increase in cost of maintenance is taken into account, the gain is decidedly questionable. As a matter of fact, the four-cylinder triple-expansion engine is at present the most satisfactory and, taking everything into consideration, the most economical for general use. The four-cylinder has replaced the three-cylinder type for several reasons. It divides the low-pressure cylinder into two, it occupies less space athwartship, and above all other considerations, it lends itself to much better balance of reciprocating parts. With the ordinary arrangement of the two low-pressure cylinders on the ends and the other two between them, the balance adopted in the Navy, or the Yarrow-Schlick-Tweedy arrangement of cranks is fairly satisfactory. In many cases the vibration of the ship from lack of balance is more apparent than real. The throb of the propeller, especially if the top is near the surface, and the pounding of the main journals, are likely to disturb one more than the vibration in the case of well designed engines. The propellers for these engines are usually fairly large in diameter and have a coarse pitch requiring anywhere from 80 to 160 revolutions per minute, depending, of course, on the size and speed of the ship. The condensers are now generally built with a cylindrical shell and do not form part of the engine support as in the early years of the vertical engine. The circulating pump is of the centrifugal type and the air pump is the usual vertical, direct-acting pump of two cylinders. For large powers it is almost always separate from the main engine so that a vacuum may be obtained without moving the main pistons. As before stated, this is the type of engine which is being replaced by the steam turbine for high-speed ships. It has its place however and will probably be used for many years to come.

The history of the steam turbine is too recent and too well-known to require extended comment in a short paper. Its application to the propulsion of ships was self-evident after the practical operation of the first Parsons turbine in 1884, but its actual use in a vessel did not come until 1894. In that year The Marine Steam Turbine Company was formed and the Turbinia was built for the purpose of trying out the Parsons turbine at sea. The first trial occurred on November 14, 1894, and many trials followed during the next two years. The principal problem was the adaptation of the screw propeller to the high-speed turbine. A single shaft was first fitted,



ARRANGEMENT OF PARSONS TURBINES FOR TRIPLE-SCREW TORPEDO DESTROYER.

but this was changed to three shafts carrying in all nine propellers. The boat was only 100 feet in length and 9 feet beam. When tested in April, 1897, she made the astonishing speed of 32.76 knots for a short time with the propellers revolving 2,000 and 2,230 times per minute. The feed-water consumption was 28.8 pounds per estimated

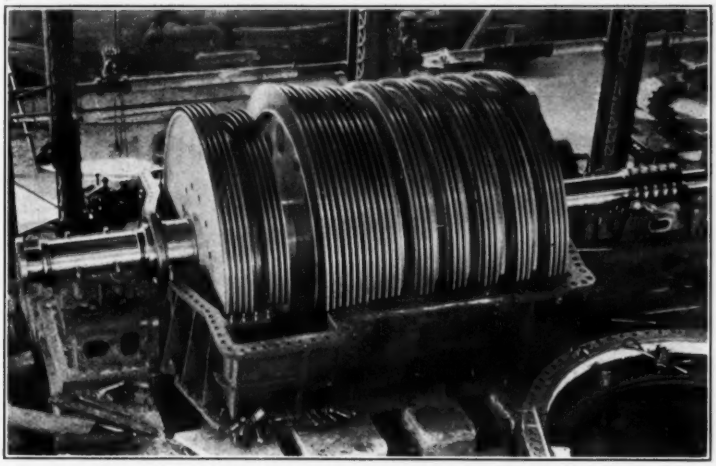


ROTOR AND CASE, PARSONS TYPE STEAM TURBINE.

The upper view shows the low-pressure rotor and top half of high-pressure case. The lower shows the high-pressure rotor in its bottom case.

horse power and the weight of all machinery and boilers chargeable to propulsion was 22.40 pounds per horse power. This figure for weight is far lower than anything attainable in large ships or even torpedo boats. The Turbinia was hardly more than a racing machine built for demonstrating the adaptability of turbines to marine propulsion at that speed. She did this admirably, and the matter was

taken up by the British Admiralty with a view to building some torpedo destroyers. The Viper and Cobra followed in 1898. The arrangement of the turbines was changed to four shafts and the turbines were connected in what has become a standard method for the Parsons turbine. The outer shaft and screw on each side was driven by a high-pressure turbine and each inner screw by a low-pressure turbine taking the exhaust from the high-pressure nozzle.



CASING AND ROTOR, SHOWING BACKING RINGS, FOR CURTIS TURBINE OF THE NORTH DAKOTA.

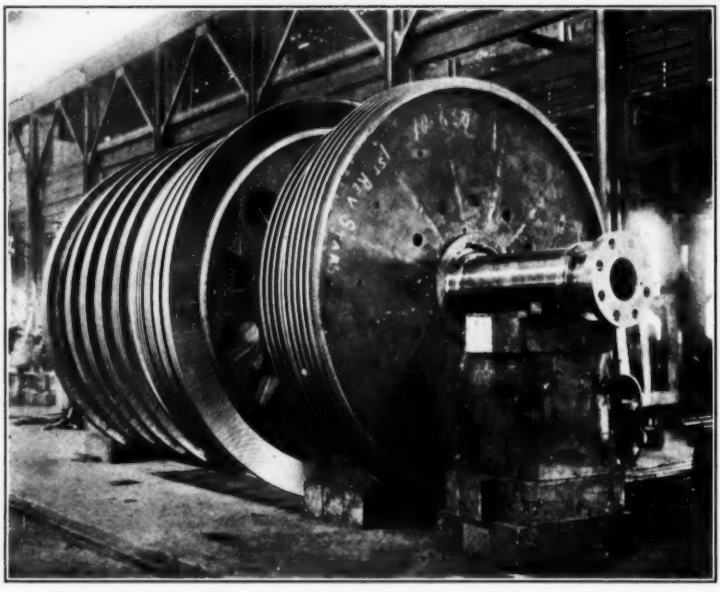
The arrangement on the Turbinia was quite different, as there the turbines formed the three elements of a triple-expansion engine. A high-pressure turbine on the starboard side took steam direct from the boiler; from there the steam exhausted into an intermediate turbine on the port side, and then it passed into a low-pressure turbine connected to the middle screw. The past ten years have yielded differences in the location and arrangement of the turbines, but the three- and four-shaft types have remained as perhaps the best for the Parsons turbine.

In the American torpedo destroyers, now building, the three-shaft type is adopted, but the high-pressure turbine drives the central propeller while the two low-pressure turbines drive the wing propellers. This is well shown in the pictures. The backing discs are in the casing of the low-pressure turbines.

The trial of the Viper broke all records of speed on the water. She made 36.581 knots for one hour, or about 42 statute miles, on 1,180 revolutions per minute. It is probable that too much was

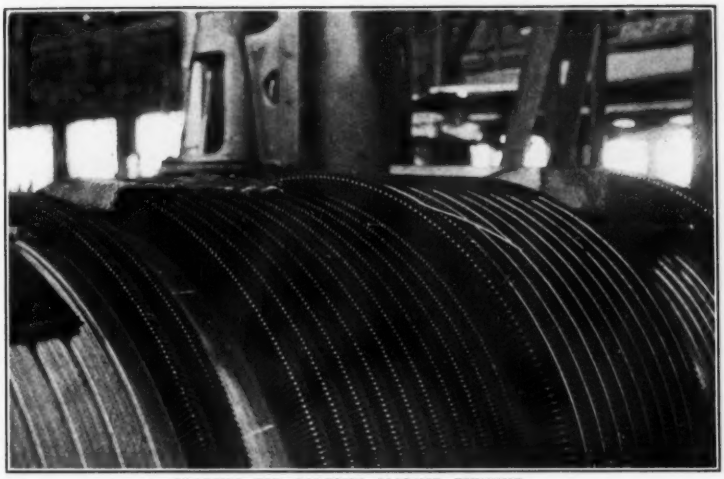
sacrificed to mere speed in these two torpedo destroyers, but the success of the Parsons turbine for marine propulsion was conclusively demonstrated. It only remained to apply it to merchant ships.

This was done in the King Edward, built by W. Denny & Bros. in 1901. She was of the three-screw type with turbines exactly as in the American torpedo destroyers. The advantage of this arrangement is perfectly plain when reversing is considered. Inasmuch as the steam turbine is not reversible, a second set of turbines, one on each wing shaft, is carried. They are placed for convenience on the vacuum end of the low-pressure turbine and within the same casings; therefore, they revolve free in a medium of low density. They are much lighter than the go-ahead turbines, having fewer stages, as economy of operation does not have to be considered.



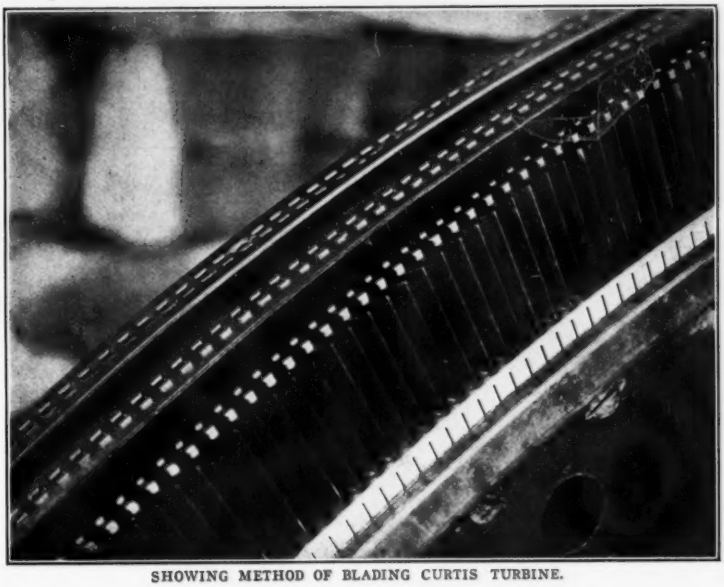
ROTOR FOR CURTIS TURBINE OF NORTH DAKOTA; BACKING RING IN FRONT.

The trial of the King Edward gave a speed of 20.48 knots, and an estimate was made to show that she would not have done as well with reciprocating engines. This estimate was necessarily unreliable. Nevertheless, the turbine had proven its capacity to develop a satisfactory speed on moderate coal consumption. The Queen Alexandra followed in 1902, and the Queen for the Dover-Calais service in 1903. As the latter was designed for a very short run, she was tested before



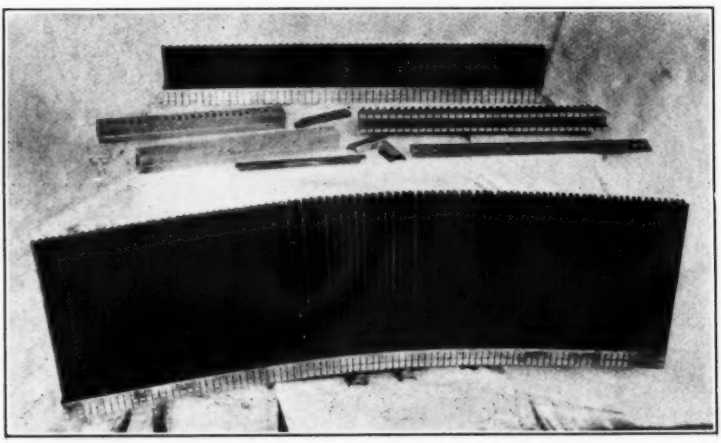
BLADING FOR PARSONS MARINE TURBINE.

acceptance for her manœuvering qualities. She made 21.73 knots when running full power ahead, and from a speed of 19 knots ahead she was brought to a dead stop in one minute seven seconds in two and a half times her length. She also made 12.95 knots when steaming full power astern.

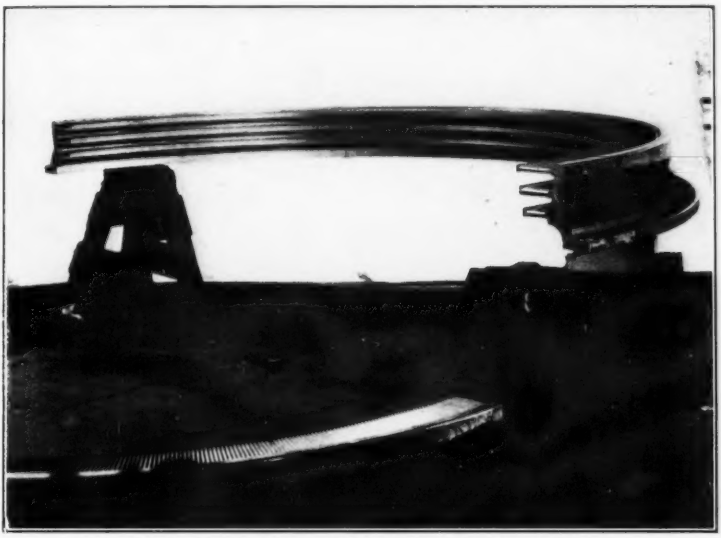


SHOWING METHOD OF BLADING CURTIS TURBINE.

The steam turbine was thus fairly launched in 1903, and it has gone from one triumph to another, culminating in the two great Cunard liners, Lusitania and Mauretania. These ships have been described so well in London *Engineering* for 1907 that anything more than a brief reference to their dimensions would be superfluous here. They have a displacement of about 38,000 tons, a horse power of 68,000 on four shafts, and a speed of 25 knots. The two wing propellers are driven by high-pressure turbines and the two central propellers by low-pressure turbines. Astern turbines in their own casings are placed on the forward end of the two central shafts. The speed of the propellers is about 180 revolutions per minute, as compared with 80 for large ships driven by reciprocating engines. These ships have fulfilled all the expectation of their builders and have once for all established the steam turbine on a firm footing as a reliable and economical method of driving ships at high speed. The record of a voyage during November 1907 gives a steam consumption of 15.35 pounds per shaft horse power for all purposes, and a coal consumption of 1.5 pounds per shaft horse power. This represents, at 24½ knots, 0.11 pounds of coal per ton displacement per knot. A discussion as to whether these ships would have been possible with triple- or quadruple-expansion engines becomes more or less academic when the enormous jump in power made by using the turbine in them is contemplated. They contain nearly double the horse power previously placed in one hull. Yet, there is no reason why reciprocating engines should not have accomplished quite as much



BLADING FOR TURBINE OF NORTH DAKOTA.



FIXED BLADES FOR TURBINE OF THE NORTH DAKOTA.

on four screws except as to economy of space, and perhaps as to economy of coal.

Besides the Parsons turbine which now occupies almost the entire field, and the Curtis which is fast becoming a competitor, there are two other types, the Zoelly and the Rateau, that may be developed into successful marine types. The last named has been tried and the results published by Mr. Rateau, but its use on a large scale is still in the future.

In the United States, the steam turbine has been slower of adoption than might have been expected, but the Parsons turbine has been put into several merchant ships. The Curtis turbine as built by the Fore River Shipbuilding Company has been successfully used in one merchant ship, and in the scout cruiser Salem, whose record has on the whole been very creditable. The battleship North Dakota is also to have Curtis turbines which are now completed ready for installation. One advantage of this turbine is the lower rotative speed than the Parsons. It is thus more easily fitted to turn large screws and it should be better adapted to low-speed ships. Its efficiency in coal consumption has not yet been fully worked out, but there is no reason why it should not do as well as the reciprocating engine at full power. If the results obtained in large power stations on shore can be taken as a guide, it should do better.

MODERN LIGHT SOURCES AND INDUSTRIAL LIGHTING.

By H. Thurston Owens.

SINCE the advent of illuminating engineering as a distinct branch of applied science, much has been accomplished and, as might be expected, a number of popular misconceptions have been righted. The subject contains many pitfalls for the unwary, especially as the majority have not as yet assimilated the somewhat hazy nomenclature incidental to a new art.

As far as the gas interests of the United States are concerned, the candle power of gas refers to the intensity in a horizontal direction of gas burned in a standard burner, as compared with a standard candle or its equivalent. Upright-mantle burners are measured and rated in the same manner. An upright-mantle burner of 60 candle power and consuming 5 cubic feet of gas per hour, has an efficiency of 12 candle power per foot, in a horizontal direction. An inverted-mantle burner gives its maximum intensity directly underneath, and it is rated according to the reading taken at that point, called "Nadir." Therefore, an inverted-mantle lamp of 80 candle power, burning 3 cubic feet of gas per hour, has an efficiency of 26.6 candle power per foot, in a downward direction. An inverted-mantle arc lamp, however, gives its maximum intensity at some 30 degrees below the horizontal, and its efficiency based upon this maximum would be of still different character. The same conditions exist in the various types of electric lamps. It is evident that the ratings as given are none of them comparable and matters are often complicated still further when measurements are made with lamps equipped with reflectors.

In interior lighting we utilize the light given in all directions, and if it becomes desirable to compare the efficiencies of sources having widely different characteristics, it can readily be done by rating them according to their mean spherical candle power. This is the average value of the light in all directions and bears no relation to the average value of all of the light from a standard candle.

TABLE I. SHOWING MAXIMUM AND MEAN SPHERICAL CANDLE POWER OF VARIOUS LIGHT SOURCES.

	Maximum C.P.	Reduction factor.	M.S.C.P.	Consumption.	Efficiency M.S.C.P. per foot.
Gas Lamps.					
Open gas flame.....	22.5	.955	21	5.0	4.02
Upright mantle.....	83	.759	63	3.7	17.02
Inverted mantle....	80	.675	54	3.0	18.00
Upright arc.....	360	.738	266	19.7	13.50
Inverted arc.....	473	.655	310	16.2	19.13
					Watts per M.S.C.P.
Electric Lamps.					
Carbon	16	.825	13.2	55	4.16
Tungsten	48	.763	36.6	60	1.63
Direct-Current 6 Ampere Arc.....	600	.355	213.0	600	2.81

The efficiency of a light source can hardly be called a determining factor for its selection until we group a number of them of very similar characteristics as regards distribution. When this has been done we can readily obtain a comparison of value. The mean lower hemispherical candle power has been suggested as a rating, but this means that we neglect the light emanating from all angles above the horizontal, and the cases where this factor can be neglected are decidedly few in number.

COLOR.—The color factor has two characteristics, one being that the energy required by a person to enable him to see is greater or less according to the color of the light, and further an object of a decided color will reflect more light from a source of similar color than one of different color value.

Many illuminants have been advertised as being the equivalent of "daylight" and others "sunlight," but only two in commercial use even approximate the former standard. The value of this quality is little understood, and except for the matching of colors is not altogether desirable. Daylight is a very cold light, and sources which are similar, namely, the Moore carbon-dioxide tube and direct-current carbon arc, are suitable only for mercantile purposes. None of the smaller units has a color value near daylight, and their nearness to this value is given by Dr. H. E. Ives* as follows:—1 Welsbach mantle; 2 tungsten incandescent; 3 Nernst glower; 4 acetylene flame; 5 gem; and 6, carbon incandescent.

REFLECTION.—The most important factor in illumination is reflection, as the greater the reflection the greater will be the economy. Conversely, the greater the absorption the greater will be the expense.

* Transactions Illuminating Engineering Society Vol. III, No. 8.

FIG. 1. ILLUMINATION BY ENCLOSED ARCS WITH METAL REFLECTORS.
The General Electric Company.

FIG. 2. OFFICE LIGHTING BY NERNST LAMPS.

Light emanating from a source in the form of waves is absorbed and reflected by all objects in its path, and the amount absorbed plus the amount reflected equals the amount received by the object. The amount absorbed is lost, while the amount reflected determines the ease with which we discern objects.

Reflection is of two kinds, regular and diffuse, although in practice there is always some diffuse reflection. In the former case light will be reflected from a perfectly smooth surface, provided it is opaque, at an angle which is equal to the angle of incidence. The application of this law may be readily seen in the various types of reflectors in commercial use.

LIGHT-REFLECTION.—When the object which receives the light is translucent, or in other words, is of such character as will permit some of the light to pass through, whether we can see through it clearly or not (being in the former case transparent), the direction of the light rays which pass through the material will be altered. This is called "refraction," and the direction which the light will take can be arranged for in the design of the enclosing globe. One point must always be remembered, however, and that is that with whatever type we use there will always be a loss due to absorption.

FIG. 3. WESTINGHOUSE ALTERNATING-CURRENT MULTIPLE ARC LAMPS.

DISTRIBUTION OF LIGHT.—None of our modern light sources should be used without some type of globe which cuts down the intrinsic brilliancy, and by selecting the proper type of globe we can materially increase the amount of light in a direction where it is required. In choosing the type of shade or globe we have three factors to deal with in the globe itself—reflection, refraction, and diffusion—and all three are to be met with in all reflectors which are not opaque; in the latter case there will only be two, reflection and diffusion.

The first class includes glass and porcelain ware, thin papers, and silks, and the second, mirrored glass and painted or polished metals.

GLOBES AND REFLECTORS.—To within comparatively recent years globes and reflectors were designed chiefly for ornament and but little attention was paid to the distribution of the light. If we take for example the globes used for open-flame gas burners, we find not only that they obstruct a large portion of the light, but also that they do not fulfil their really useful purpose of steadying the light. Upon the introduction of incandescent electric lamps a somewhat similar globe was usually provided, but with worse results than in the case of gas lamps, because they were not needed to steady the light, but they were needed to diffuse it and they rarely accomplished this result.

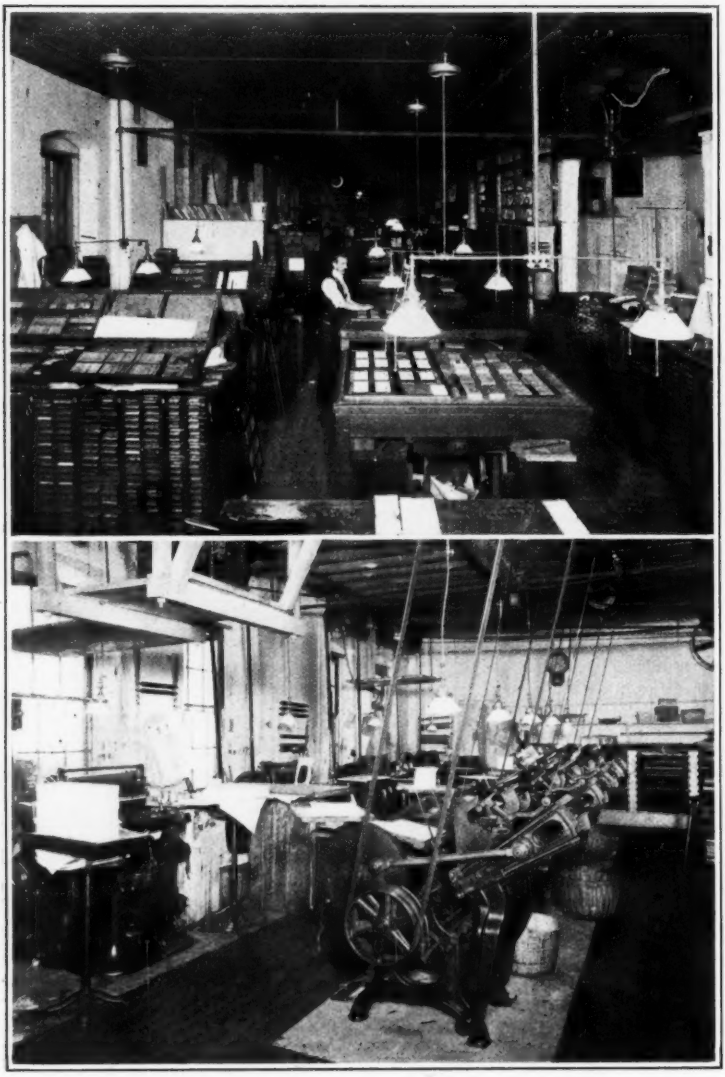
The selection of an illuminant should be made with proper regard for the eyes of the persons who are to use the light, but strange to say this has not been common practice. We hear many complaints regarding defective eyesight due to electric light, but by exercising a reasonable amount of care and foresight these troubles can be avoided. Electric arc and incandescent lamps and mantle gas lamps should be covered with some type of diffusing glassware, unless the sources are placed high and well out of the line of ordinary vision.

OFFICE LIGHTING.—In large offices where it is likely that desks will be shifted considerably, it is good practice to provide for general illumination only, as in the case shown in Figure 2. The lamps in this case are of the Nernst type, equipped with light opal globes; they have a low intrinsic brilliancy and a pleasing color.

The objection to lighting arrangements in offices where only lamps for general lighting are provided lies in the fact that the light has no direction, with the consequent loss of shadows.

READING LAMPS.—When individual lamps are provided they are quite generally of too high candle power and are rarely located so that the light comes from behind and above. In small rooms the reading lamp can be placed upon the central chandelier and thus light the room as well. In large rooms, where desk lighting is

FIG. 4. PIERCE AUTOMOBILE WORKS, BUFFALO, N. Y., LIGHTED BY COOPER-HEWITT MERCURY-VAPOR LAMPS.



FIGS. 5 AND 6. ILLUMINATION BY INVERTED MANTLE GAS LAMPS.
The Welsbach Company.

provided, there should always be lamps for general illumination, but of low intensity.

INDUSTRIAL LIGHTING.—In the lighting of factories and workshops the question of least importance, as far as economical operation is concerned, is the type of illuminant to be used. The essential feature is the location and the equipment of the light sources.

FIG. 7. GAS-ARC LIGHTING INSTALLATION IN AN AUTOMOBILE SHOP.
The General Gas Light Co.

General illumination should always be provided by means of lamps hung close to the ceiling and, wherever practicable, walls and ceilings should be light in color, as the amount of illumination on the working plane will be from 25 per cent to 50 per cent greater than in dark-colored rooms.

The assembling room illustrated in Figure 1 is a good example of sufficient general illumination for all purposes. A high suspension always tends toward a more uniform distribution, which is especially desirable on account of the large pieces of apparatus handled in this case. The lamps here are enclosed arcs with special oval outer shade,

FIG. 8. FLAMING ARC LAMPS INSTALLED FOR LIGHTING THE GÖRLITZER STATION, BERLIN.
Chas. L. Kiewert Company.

which throws most of the light against a corrugated metal reflector, acting as an excellent diffusing surface. In large buildings where the ventilation is good the flaming type of arc lamp can be used to advantage, but they are not as steady and require much greater attention.

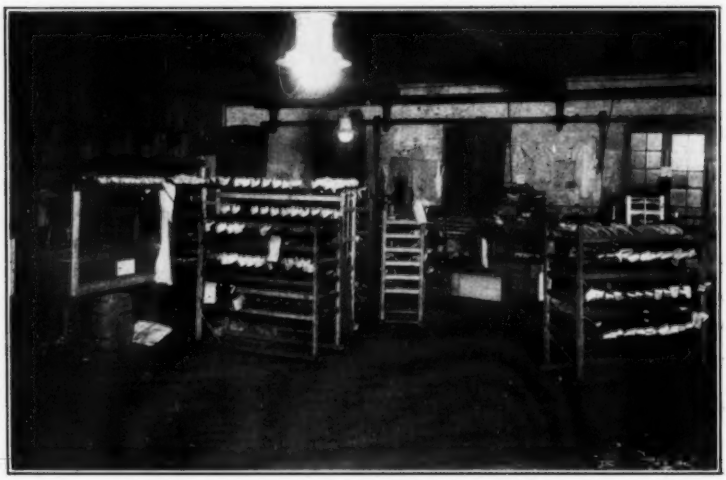


FIG. 9. LIGHTING BY RAMSDELL INVERTED GAS ARC LAMPS.

In workshops with ceilings of ordinary height and with a large number of machines, such as the one shown in Figure 3, a larger number of smaller units would probably be more satisfactory than the arc lamps which are shown.

TUNGSTEN LAMPS.—This is a field where the tungsten type could be used to advantage were it not for the fact that at the present time the filaments are far too fragile. As these are being continually improved the time is not far distant when they may be so used.

MERCURY-VAPOR LAMPS.—There is another type of the so-called "high-efficiency" electric lamp which operates upon about 0.5 watts per candle—the mercury-vapor lamp. Where there is much moving machinery, as in the case shown in Figure 4, the troubles from annoying shadows are considerably reduced. The principal value of this lamp lies in its peculiar color, a peculiar green, very unpleasant at first, but owing to the absence of red rays details are very clearly brought out. This is most important in cloth mills where imperfections may be readily detected.

FLAMING-ARC LAMPS.—In lighting large areas, both interior and exterior, where a high suspension is possible, the flaming arc lamp is a most satisfactory and efficient illuminant. An instance of this kind is illustrated in Figure 8, being a railroad terminal and yards in Berlin, Germany.

GAS LIGHTING.—All the advantages of electric lighting, and usually at a decreased cost, can be obtained with gas lamps. It is essential, however, that the lamps be maintained properly and this should be done wherever possible by workmen in the employ of either gas companies or gas maintenance companies. With the inverted type 20 candle-power lamps consuming only one foot an hour, and with the larger sizes, several hundred candle power can be obtained. This type of lamp, shown in Figure 9, requires more delicate adjustment and slightly higher pressure than the upright, but if properly maintained should give better satisfaction. Where neither gas nor electricity is available acetylene plants can be installed with much less danger from explosion than has formerly been the case with this illuminant, and it is the best substitute at hand.

The type of gas lamp which has proven most satisfactory for general illumination is the gas arc, as shown in Figure 7, in this case being of the upright type. That they are not subject to troubles from dust is evidenced by the installation illustrated, showing a plant where automobile bodies are manufactured.

Special Work.—For special work it is important that a lamp be equipped with a reflector, so as to protect the eyes of the workman from the direct rays and throw the light where it is required. Reference to the subject of shading our eyes from the glare of our modern light sources is made again, as it is the worst feature of our present lighting systems. The gas lamps shown in Figures 5 and 6 are well adapted for the purpose at hand, being small units located where the light will be thrown to advantage. In order to overcome the breakage of mantles due to vibration, an anti-vibrator has been installed near the ceiling upon each fixture. See Figure 5.

In order to obtain the greatest benefits from the more efficient forms of light sources which have been introduced in the last few years, much more care and attention must be given them than had been the custom with the older types; but the results are well worth the time and labor involved, as it is not a question of illuminating engineering so much as one of hygiene. We should look for better workmanship rather than reduced lighting bills, and in that way obtain the benefits of these improvements.

MACHINE-TOOL PRACTICE FOR MAXIMUM PRODUCTION.

By Charles Day.

Mr. Day's article is the first of an important series of six, defining the settled principles of machine-shop practice for maximum production, including the design and operation of tools, the choice of equipment, the determination of processes, and the layout, construction and operation of the shops themselves.—THE EDITORS.

MACHINE-TOOL practice for maximum production has commanded so much attention during the past few years that there is a natural hesitancy to undertake a summary of the subject in an article which must be addressed to an audience as expert as the majority of readers of this magazine. However, upon contemplating the matter, it seemed that the status of shop practice can today be somewhat more clearly defined than at any time since the advent of the high speed steels and motor drives, and possibly with this thought in mind a slightly new point of view can be had.

When one considers the important part that the metal-working industry has played in the development of present-day civilization, he is forced to conclude that the rapid evolution that it has but just undergone will reach far beyond the bounds of the shop and factory. Our attention, as a rule, is so centered upon our immediate concerns that we overlook the broader aspects of the machine-shop problem, and so lose the keen interest that must certainly spring from a realization of the substantial advancement in human progress that can be readily traced to the metal-working arts. This is a phase of the subject that we cannot afford to ignore, for the broader our understanding of the reasons governing industrial advancement and the part played by the line of work in which we are directly engaged, the more effective can our efforts be made.

The foundation of modern business and society commenced with the first general utilization of iron and steel. The advent of the railroad marked a revolution in personal and business relations, and the steamship in international affairs, and yet both of these were made possible by the work of comparatively few men. To-day a very considerable part of the population of progressive nations is engaged

in businesses having to do with the production of metals and their manufacture; therefore, fundamental improvements in the art of metal working have a far-reaching effect. They make possible the manufacture of more useful articles at lower costs, and open new fields where satisfactory accomplishment was formerly impossible. The perfection of special steels for severe duty, and of means for working them, is creating more reliable and higher-speed train service; and modern shop practice has perfected the automobile. We have but just learned that mechanical flight has been attained, and yet the historic work of many able investigators probably would not have been consummated by the Wright brothers, notwithstanding their remarkable researches and experiments, had not advances in metal working made possible the present highly efficient hydrocarbon motor. And who will attempt to prophesy the distance and breadth that the Wrights' accomplishment may reach?

In the final analysis, the real interest attached to the performances of machinery of any kind has to do with the usefulness of the work done, and if from this standpoint the measure is not satisfactory, it has no permanent worth. Certainly, the metal trades, considered as a whole, have contributed liberally to the needs of civilization.

A study of the development of the machining of metal shows that during the period commencing with the work of Maudslay, who may be considered the father of most of our modern machine tools, and terminating only a few decades in the past, advancement had to do chiefly with the designing of new types of machines, and supplying them to the rapidly growing demand. Since that time effort has been directed principally to the more economical performance of machine work, and "efficiency" has been the watchword. For some time after the invention of the steam engine it was sufficient to make an engine that would run satisfactorily. Today, as a result of widespread competitive conditions, efficiency in operation and efficiency in manufacture are of almost equal importance.

Everyone interested in machine-shop work is familiar with the marked development of recent years. The subjects of high-speed steels, motor drives, machine tools for heavy duty, equipment for the handling of materials, and the systems of management required for directing the operators of machinery of all kinds, have been constant and at times heated subjects of debate, and the attention so given to them has, necessarily, been most fruitful of results.

It has been mentioned that shop practice, which includes all the factors just referred to. is nearing a stage. approaching *standardiza-*

tion, so that a *résumé* of existing practice and a brief allusion to modern types of machinery may prove of interest.

About ten years ago there were a number of men who were actively engaged in work that had to do with the more effective administration of industrial work, and especially machine-shop work; but it is a question whether general interest would have been awakened in this subject, to anything like the extent that has proved to be the case, if certain revolutionary advances had not been made concerning the physical features involved in metal-working plants. We can properly assume that present machine-shop practice, as it is now exemplified in many concerns, received its greatest impetus through the introduction of high-speed cutting tools and the motor drive, and it is appropriate that consideration first be given to these.

The machine-shop problem, in its most elemental sense, resolves itself into one of removing chips from the parts upon which work is to be done. This is equally true whether we consider a lathe tool removing a heavy turning from a locomotive tire, a file smoothing a metal surface, an emery wheel cleaning up the face of a rough casting, or a scraper putting the finishing touches on the shears of a lathe. Tool steel is used for by far the greatest amount of work, so it should be expected that any marked improvement in its composition or method of treatment, making possible the removal of a greater quantity of chips in a given time, would result in many radical changes in shop methods. Machine equipment in use when the high-speed steels were introduced proved to be so unsuited for the new demands that it was soon clear that no half-way measure would be sufficient, but that it was necessary immediately to reconsider the whole subject of metal-working from an entirely new standpoint. Just at this time the motor drive was being strongly advocated by the companies manufacturing such equipment, and it was evident almost from the start that the individual motor drive for machine-tool operation promised a satisfactory solution to the new problems of greater power and better speed regulation. This condition resulted in a close competition for supremacy between tool steel on the one hand, and the machine tool upon the other. Another factor that proved to be important was the comparatively high cost of the new tools. To equip the tool room properly in a shop employing several hundred men required the expenditure of several thousand dollars, so that in many instances the management became insistent upon the *efficient use* of the new steels. In order to accomplish this it was found necessary to resort to much more

effective methods of management than had formerly been customary, and so the foundation was laid from which has evolved the machine-shop practice of today.

The efficiency of work performed in a machine shop, whether large or small, as a rule can be quickly arrived at through an investigation of the tool room and the department for the manufacture of jigs and other accessories; for although these departments occupy but a small part of the total shop-floor space, they serve to illustrate the policy and ability of the management. Their proper conduct involves practically all the functions that are required for the operation of the shop proper; and further, the efficiency of the productive work is to a large extent dependent upon the character and completeness of the equipment stored in the tool room.

Modern systems for shop administration may be successful, through methods of compensation, in establishing work to the full extent of physical endurance, yet this alone will not result in economic conditions. The training of the individual operators is the more essential requisite. Training, in itself, implies that the trainer must have as his object a certain definite accomplishment which can be achieved only through the standardization of methods and facilities. The competent professional baseball pitcher could never attain the proficiency now usual if the ball that he uses had not been standardized almost exactly as to weight and size. In this instance the equipment —namely, the baseball—can be readily standardized once for all, and the individual skill of the player is the governing factor. In the machine shop, however, the involved character of the equipment causes it to assume a more important part, and the operator's manual skill is not as essential as the knowledge he has concerning the method of adjusting his machine for different work. The determination of such methods can, however, be attained only as a result of painstaking scientific work, and accomplishment once achieved can only be duplicated provided the same conditions as regards tool steel, machine, and character of material worked are capable of exact reproduction. When it was found that thorough analysis and scientific study resulted, as a rule, in the establishment of methods requiring not more than one-third of the time necessary for the performance of the work when it was planned by the machinist himself, it became evident that old methods would have to give way to the new. So it is on this account that, today, standardization in regard to shop equipment is receiving just as much attention as the standardization of parts entering into the finished product.

The starting point for standardization is always in the tool room, and properly begins with the cutting tools. The adoption of standard shapes and sizes for lathe tools, boring cutters, and even chisels, is now the general practice, as is also the method of forging and treating the tools. Even in small shops it pays to have one man grind all the tools, absolutely prohibiting the workmen access to any grinder for this purpose. Tool steel is now bought by several large users according to specifications, different compositions being specified for different classes of tools, and it is likely that this practice will become general.

While what has just been said regarding cutting tools is now generally appreciated and acted upon, the same attention is not given to many other accessories which rightly form a part of the tool-room equipment. All clamping bolts and wood blocking should be standardized, and in certain cases it is now the practice always to issue, with a set of bolts, a standard wrench that exactly fits the nuts. When these bolts are returned to the tool room each one is examined, to see that it has not been damaged and that the nut is hand loose, and if this is not the case the parts are not returned to the racks until they have been repaired.

The old practice of each machinist personally securing from the tool room the tools and other auxiliary equipment that in his judgment are needed is rapidly giving way to the system of providing in advance for each operator all of the tools and other parts that are required to consummate the work in a predetermined manner. The advantage of this method is so great that to some extent at least it is being followed in almost all large shops, even though standard instructions for performing the work are not given to the workmen, or, in fact, may not be on record.

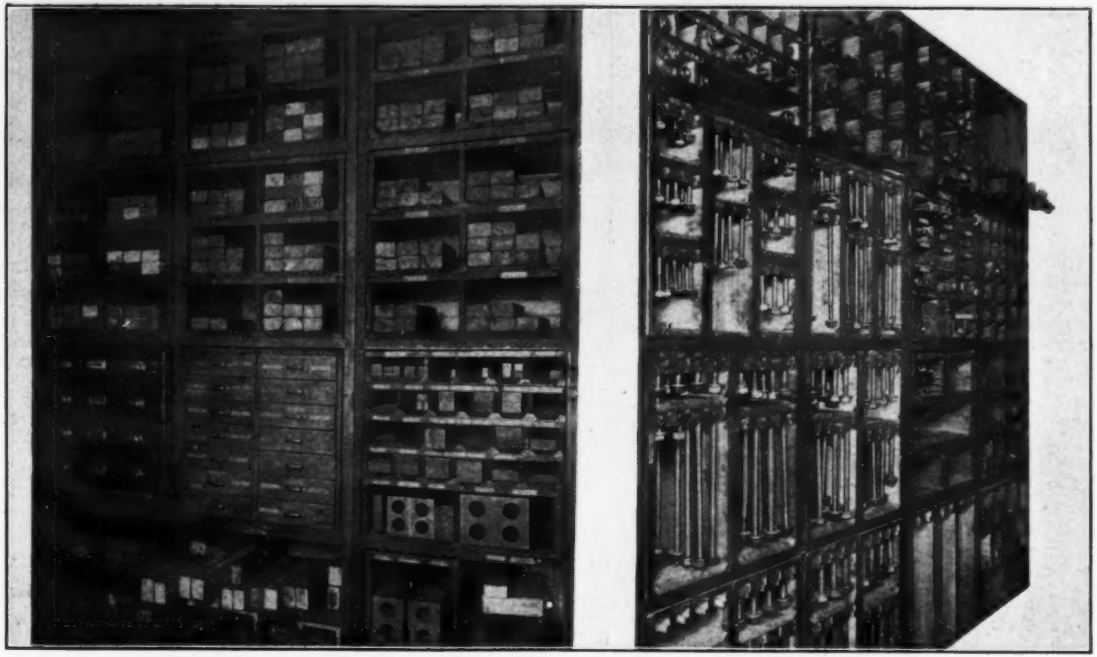
It is customary in large machine shops to confine the tool room to storage purposes only, all grinding and tool making being done in a separate department, which work in some cases is not fenced off from the rest of the shop. The desirability of this plan, as well as many other procedures that are followed in up-to-date plants, depends to a considerable extent upon the number of men employed and the character of the work. The function of the tool room, however, is always the same; and to preserve it properly it is necessary to draw a sharp line between the making, care taking, and issuing of tools, and the productive work in connection with which the tool-room equipment is used. We can conclude from the above summary regarding tool-room management that present-day practice

promises to result, very soon, in a general standardization, and that the modern tool room far surpasses in its usefulness the carelessly managed tool departments that were usual a few years ago.

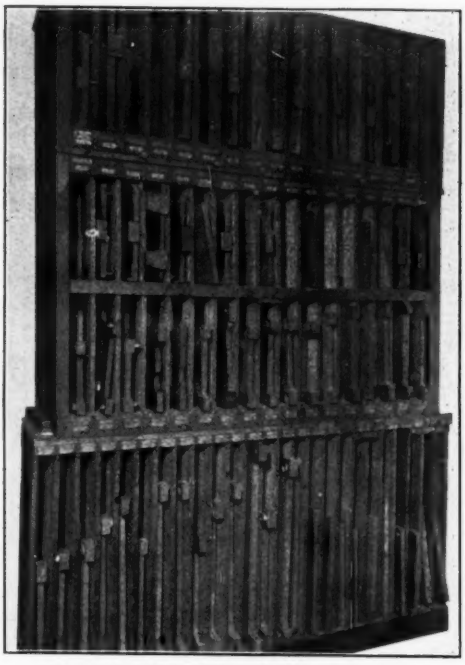
A very interesting example of the standardization of lathe and planer tools on a large scale is the central tool-dressing plant recently established at the Philadelphia Navy Yard, which supplies to all navy yards on the Atlantic Coast high-speed lathe and planer tools, which have been forged, treated and ground to standards. Each of the various yards is equipped with an automatic grinder for regrinding the tools until they require redressing, when they are returned to the central tool-dressing plant at Philadelphia for replacement by newly dressed tools. The great advantages of this scheme are that all yards are equipped with tools of standard shapes and of uniformly high quality, and as the forging, dressing, and grinding of tools are done in large lots, substantial reductions in cost result. This system for the standardization and distribution of tools was introduced at the Philadelphia Navy Yard by H. K. Hathaway, and it sets an example that will probably be followed by railroads and other large concerns operating a number of machine shops.

Owing to the importance of the question of storing small tools and accessories, a number of illustrations are included in this article which are typical of present practice. The sectional racks shown are in the tool room of the Tabor Manufacturing Company, Philadelphia, and are particularly interesting as they provide special receptacles for many parts, such as bolts, wood clamp blocks, and other auxiliary equipment which, until recently, were not standardized or carried in the tool room.

When the motor drive was placed on the market, the requirements of machine tools (that is, the requirements of the cutting tools) were so vaguely understood that the subject of individual drive proved for a long time a very complex problem, with the result that many conflicting views arose among the machine-tool designers and shop managers. However, this very condition was instrumental in rapidly developing motors adapted to a wide range of requirements, and now that the subject is better understood and opinion is in large measure unified, we find that the problem has been most satisfactorily and simply solved. The power and speed requirements of shops doing different classes of work vary widely. A jobbing shop represents one extreme, for miscellaneous work necessitates wide ranges in speeds and in power demands. At the other extreme we have



SECTIONAL RACKS, TOOL ROOM OF THE TABOR MANUFACTURING COMPANY, PHILADELPHIA.
On the left are seen the wood clamp blocks and on the right the bolts, etc., standardized for each job and methodically kept in place and in order.



SECTIONAL RACKS FOR TOOL-ROOM STORAGE OF JIGS, ETC.
Tabor Manufacturing Co.

establishments doing purely manufacturing work, such as the making of sewing machines or cash registers, in which cases the machine equipment is largely special and such changes in speeds as required are usually obtained automatically. Therefore, the shop handling miscellaneous work offers the greater opportunity for the effective use of the variable-speed characteristics of certain systems of motor drive.

It is no longer necessary for the machine-tool builder to resort to guess work in selecting motors for the operation of the tools he builds. The exhaustive tests that have been made concerning power required when machining different materials and for different combinations of speeds, feeds, and depths of cut enable him to determine power requirements with accuracy, and the character of work a given machine is designed to handle, considered along with prevailing practice regarding methods of operation, enables him to arrive at the desirable variation in motor speeds. The total range in spindle speeds that is desirable is dependent upon the ratio of maximum to minimum diameters of work, or if the work is stationary, upon the ratio of maximum to minimum cutter diameters; the range is also dependent upon the ratio of the hardest to the softest material to be machined and upon the kind of operation, whether cutting, filing, polishing, etc. The number of intermediate speeds that should be available throughout the total range is governed by the uniformity of the material worked, the uniformity of the cutters, the number of feeds, and the means that the workmen have at

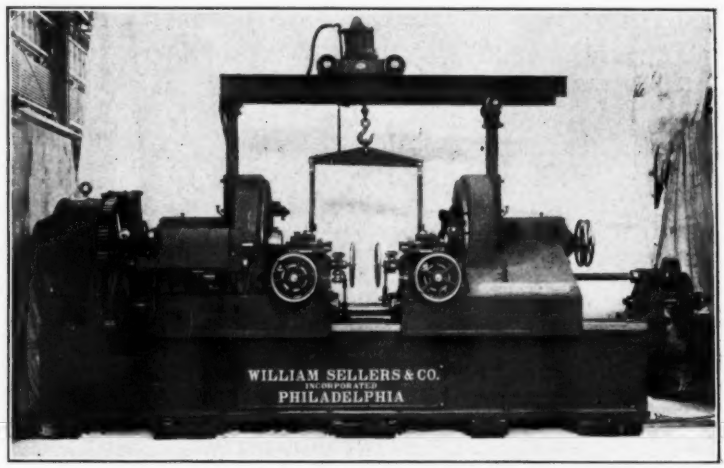
hand to determine the proper speed. The amount of power required for machines where tool steel is used depends upon the character of material and tools, the cutting speed, the depth of cut, the feed, and the shape of the cutter and the friction load. The power required for grinding machines, punching and shearing machines, and machines for changing the shape of materials without removing any metal is dependent in each instance upon factors special to these classes of work. In practically all cases, there are now available data which are sufficiently accurate to be used as a guide by the companies building machines suited to any of the purposes enumerated.

The practice of using direct-current motors for variable-speed drives has become so general that it can practically be considered standard and is not likely to be supplanted until radical changes in alternating-current motor designs have resulted. It is conceded by most men who have made a study of the subject that a range of three to one in motor speeds will satisfactorily meet most cases, and that a range of two to one is frequently sufficient. The direct-current motor of the field-weakening type will perform very satisfactorily through these ranges, and as the controlling apparatus is simple and no special system of wiring is required, this type of equipment is now being used almost exclusively.

SECTIONAL RACKS FOR ARBORS, BORING BARS, CUTTING TOOLS, ETC.
Tabor Manufacturing Co.

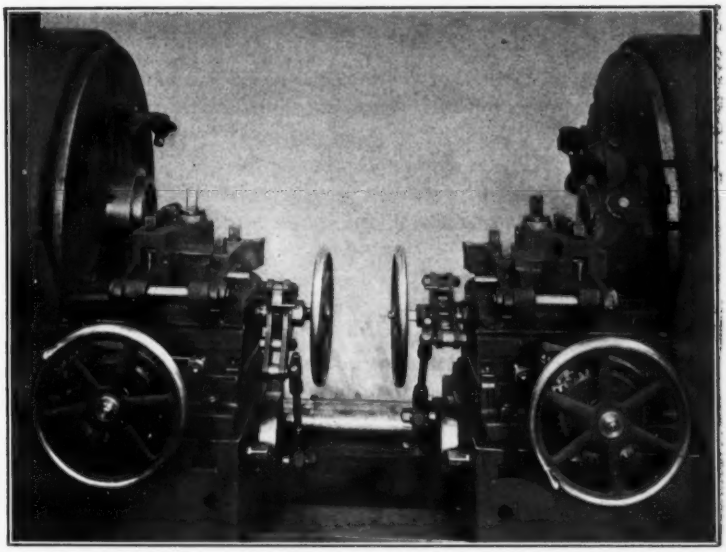
There are certain tools in almost every machine shop which can be driven advantageously by arranging in groups and belting them to short lengths of line shafting which in turn are driven by constant-

speed motors. If the shop is a small one and the requirements of certain tools can only be satisfactorily met through the use of individual motors, it is best to adopt a direct-current system throughout. The requirements of very large plants comprising a number of shops spread over a considerable area can, however, be most economically served by generating alternating current, using induction motors where constant speed will serve and direct-current motors driven from a rotary converter or motor-generator set for the variable-speed machines and traveling cranes. In this way the current can be distributed at higher voltage than would be practicable if the direct-current system were adopted, with a consequent saving in cost of distribution. This plan has been adopted for a number of the large plants recently built, including certain railroad shops.



SELLERS WHEEL-TURNING LATHE, FRONT VIEW.
William Sellers & Co., Inc.

It will probably be of interest at this point to cite the performance of a machine tool designed with an understanding of the factors with which we have dealt and operated by a man who has been properly trained and has available all necessary information regarding the work to be performed. A case of this character was recently illustrated in the machine shop of William Sellers & Co., Inc., when a test was made upon a new car-wheel lathe designed especially to meet the requirements of railroad shops. It will be recalled by those who are familiar with railroad work that not many years ago the



NEAR VIEW OF TOOL HOLDERS AND CHUCKS, SELLERS WHEEL-TURNING LATHE.

time for turning a pair of car wheels averaged about 1½ hours, and when ten pairs could be turned out on one lathe in a working day of 10 hours it was thought that about the best possible record had been attained. This rate of work has, of course, been gradually increased since then and the results cited below exemplify the economies in time that recent methods have brought about. Three pairs of 36-inch steel-tired wheels, selected at random from a large number shipped to the machine-builders' plant by the Reading Railroad Company, were turned in an average of about 20 minutes per pair, including the time of setting, machining, and taking out of the lathe. The actual time that the machine was in operation averaged about 18 minutes per pair, and the fact that 90 per cent of the total time required represents the period that the machine was doing effective work is a very significant factor. As a rule, greater economies can be accomplished through devising means for reducing time required for setting up work and taking it out of machines than in connection with the reduction of the actual machining time. In either case the economy comprises the saving effected in wages and in the overhead expenses chargeable to the work on account of the investment in equipment and building accommodations, but the time that the machine is idle is, as a rule, not given as much attention as

the time for machining, which accounts for the substantial reduction that can often be made in this direction.

Returning to the Sellers car-wheel lathe, it will be noted by the illustrations that it is motor-driven, the direct-current, field-weakening type of equipment having been adopted. The machine was designed throughout to permit of the fullest performance of the modern high-speed steels, and the arrangements for motor control, gear changes, tool adjustments, etc., have been worked out with a view to making all of these convenient to the operator and easy of accomplishment. The tools that were used were carefully selected for the work and forged and ground to shapes that had previously been found best. The operator was thoroughly conversant with the work to be done and the handling of the lathe. He knew just how much speed the tools would stand for a given depth of cut and feed, and his training had been such that he could efficiently operate both heads of the machine simultaneously.

It was stated that the tests just referred to illustrate the high degree of efficiency that today characterizes machine-shop practice. The article that will appear in the next issue will include a somewhat more detailed consideration of machine-tool design and operation, as well as additional illustrations of modern types of equipment and motor-drive applications.

EDITORIAL COMMENT

Standardization.

THE twelfth annual meeting of the American Society for Testing Materials, which will be in session from June 29 to July 3, affords by its programme an interesting index to the important progress that is being made in standardization. Whatever fears some observers may entertain as to the unfavorable "crystallizing" effects of private standardization (that is, ultra-standardization of patterns or products by individual manufacturers), there can scarcely be two opinions concerning the desirability of public or general standardization in the directions laid down by the plans and programme of the Society. Even a superficial examination of the work outlined in the various sessions is sufficient to show the energy with which the Society is extending its boundaries, and the breadth and diversity of the territory already brought under its influence.

The committee reports, under the heading of iron and steel alone, cover the subjects of Standard Specifications for Iron and Steel, Standard Specifications for Cast-Iron and Finished Castings, Heat Treatment of Iron and Steel, Standard Specifications for Cold-Drawn Steel, the Corrosion of Iron and Steel, Preservative Coatings for Iron and Steel, Standard Specifications for Staybolt Iron, and Uniform Specifications for Boilers. Under other structural materials, committees will report on Standard Specifications for Paving and Building Brick, on Fire-Proofing Materials, on Reinforced Concrete, on Standard Specifications for Cement, on Standard Specifications for Grading Structural Timber, and on Standard Specifications for Clay and Cement Sewer Pipes. Other reports will be upon Standard Specifications for Hard-Drawn Copper Wire, Standard Specifications for Coal, and Standard Methods of Testing. Further than this, the contributed papers deal with many of the most important problems in structural engineering work, including prominently the very active topics of steel manufacture and the cause and prevention of rail fractures, the protection of metal structures against corrosion, and the examination of materials for improved forms of highway construction.

Engineering Education.

ANOTHER very interesting convention, almost immediately preceding the meeting just referred to, will be that of the Society for the Promotion of Engineering Education, which will divide its sittings between Columbia University, Pratt Institute, and the Engineering Building, and will have closed its meeting at about the time these pages appear.

While the deliberations at Atlantic City have to do with engineering *material*, those in New York and Brooklyn concern the standardization of engineering *personnel*. It is apparent to an observant onlooker that within the past two years a new spirit has appeared in the long quiet bodies of the university faculties of the United States, and it has already exhibited such force and vigor as to cause a change of attitude and of relations between the faculties and the active members of the profession outside of university boundaries. There appears to be a realizing conviction that engineering education, as formalized in the schools, has been growing out of parallel with engineering practice, and that the courses need some readjustment: and the heartily encouraging

symptom is that this conviction is recognized most keenly and has been acted upon most vigorously by some of the engineering professors themselves. The college year just closed witnessed some radical changes both in curriculum and method, inspired immediately by the purpose to make engineering education fit the graduates more perfectly to the positions they would be expected to fill after graduation; and no doubt another year will see the same ideas given larger expression where they have already been active, and given place also in institutions where they have not yet been accepted, or at least have not yet been put into effect.

The Importance of Mechanical Equipment.

TO the manufacturer, the problems of men and of materials have long seemed to make up the larger part of the entire sum of conditions with which he has to deal; and most of the earlier methods of treating the wage question, or that less tangible but vitally important question, the distribution of expense, are based upon the assumption that either the man or the piece of material upon which he works is the fundamental unit. It remained for Mr. Fred W. Taylor in the field of wages, and for the apostles of the machine-hour system in methods of accounting, to emphasize first the fundamental point that it is *not* the man alone, but the man *plus* the machine he tends, that must be taken as the basis for all calculations in the larger number of manufacturing establishments. Year by year machinery fills a larger place in the scheme of production, and as competition increasingly compels us to study economy, it becomes needful to know not only what will stimulate workers to the highest activity, but also what tools and appliances will enable those workers to produce the output at the lowest cost and in the largest volume. This has really become a larger question than that of labor. Experts in the management of men begin by seeing that the most efficient mechanical equipment is provided, and that all conditions which might interfere with mechanical efficiency are corrected.

No justification, therefore, is necessary for devoting to the subject of equipment so large and so serious attention as is given to it in this issue. The present period of return to activity makes this careful study highly appropriate. Immediately succeeding issues of THE ENGINEERING MAGAZINE will follow the very interesting undertaking of expressing clearly and authoritatively a body of principles in the new science of production—not merely examples of practice, but formulated laws and data drawn from thorough and careful analysis of practice, and expressed in such form as to be applicable to any business or to any set of conditions.

The Call to Forest Conservation.

FIGURES just published by the Department of Commerce and Labor of the United States seem to reflect conditions that emphasize the often-uttered warning against the near-by exhaustion of timber supplies on the North American continent. Although the canvass made by co-operation of the Census Bureau, the Forest Service, and State Forest Commissions was closer than ever before, taking account of the cut of 31,231 mills in 1908 as against 28,850 mills in 1907, the figures show a falling off in production of 17 per cent. The lumber made declined from 40,000,000 thousand feet, board measure, to 33,000,000, the lath cut being reduced in about similar measure and shingle alone showing a slight increase. And quite as suggestive of waning resources is the progressive trend toward an increase in the use of minor and less abundant woods.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

THE PROTECTION OF ELECTRICAL MACHINERY IN COAL MINES.

INVESTIGATIONS ON THE SAFETY OF WORKING ELECTRICAL PLANTS AND THEIR PROTECTION AGAINST EXPLOSION.

Sidney A. Simon—Institution of Electrical Engineers.

SO far as danger to persons and property is concerned, except in one particular, electricity in coal mines does not differentiate itself from electricity in a large number of other branches of industry. The danger of ignition of firedamp in gaseous mines by the sparking of electrical apparatus is, however, of such supreme importance that the problem of adequate protection of electrical apparatus against explosion may properly be called *the* problem in the application of electric power in collieries. Of the many investigations which have been made on the subject, one of the most important series of experiments has had but little publicity outside of Germany. The conclusions reached from these tests, which were carried out in Westphalia during 1903, 1904 and 1905, are given in a paper read by Sidney A. Simon before the Glasgow Section of the Institution of Electrical Engineers, of which a brief abstract follows.

The tests were carried out conjointly by six of the leading electrical engineering firms in Germany, and the Committee of the Westphalian Mining Fund, at special experimental galleries furnished by the latter. In these galleries the apparatus to be tested was operated in explosive atmospheres, both of air and actual firedamp, drawn from unused workings below the surface, and of air and fine coal dust. The trials covered three years and were divided into three distinct series: 1903, tests of special apparatus and machines submitted by the firms concerned; 1904, tests to determine suitable means of protecting apparatus and machinery to avoid explosion; 1905, tests on motors provided with the protection.

"The tests of 1903 showed that practically all the protective devices fitted to motors proposed were either insecure and a positive danger in an explosive atmosphere, or ineffectual for mechanical or electrical reasons. Such, for example, were enclosing of complete motor with wire gauze or solid covers, enclosing of overhung slip rings in solid so-called gas-tight covers, or immersion of slip rings in oil. So far as the total enclosing of the complete motor or of the slip rings was concerned, it was found practically impossible to prevent the entrance of explosive mixture into the interior, especially if the motor were frequently started and stopped, with consequent alternate heating and cooling of the enclosed gases.

"If sparking occurred in the service of these motors, an internal explosion occurred, which generally either blew the enclosing covers off, otherwise damaged the motor casing, or expelled flames and ignited gases through the bearings and oil wells, thus in most cases communicating the explosion to the surrounding atmosphere, It was found, however, that

if gaps were provided of a certain size, *i.e.*, not too small to prevent the egress of the heated gases and cause a dangerous rise of pressure, and not so large as to allow free passage of the burning gases, the communication of the explosion was avoided.

"The covering of the openings with wire gauze (even with two layers) was not found altogether satisfactory. In many cases this may have been due to the too coarse mesh which had been provided, but generally it was found that the gauze did not offer sufficient cooling surface relatively to the large volume of gas enclosed to prevent its being raised to a dangerous temperature, and finally allowing the explosion to be communicated to the external atmosphere. A curious phenomenon was observed with this method of enclosure which also tended to render the protection ineffective: the continued combustion inside the motor of firedamp after the first explosion had ignited it. As combustion proceeded, the hot products were carried off through the gauze at the top of the motor, and fresh firedamp was introduced below to take its place and thus feed the flame. The consequence was that the gauze was soon raised to a very high temperature and destroyed, and an explosion took place in the gallery.

"A further disadvantage of this class of motor is an electrical one, due to the very small amount of ventilation which the fire-meshed gauze required permits, in deference to which it is necessary to design the motor practically on the same lines as a totally enclosed one, so that the electrical characteristics are not of the best, and the motor is large, heavy, and high in price.

"In the case of slip-ring motors the immersion of the slip rings in oil was found to cause difficulties of an electro-mechanical nature, which entirely precluded their employment.

"In consequence of the negative results of these trials, the second series of experiments (of 1904) was undertaken. In the first place, the nature of the explosion was studied, and how this depends on the volume of gas, quality of the mixture, configuration of the enclosing casing, and position of the origin or point of ignition. In particular, observations were made on the extent to which the nature of the explosion was modified by introducing partitions with orifices and other obstacles."

Experiments with various sizes of closed vessels free of internal obstacles showed that the actual rate of explosion of a mixture of firedamp and air depended to some extent on the shape and volume, but the maximum pressure was practically independent of these variables. When the volumetric percentage of methane is about 7 to 8 per cent, the maximum pressure of the explosion is about 6½ to 7 atmospheres, and is reached about one-fifth of a second after ignition. With a smaller or larger percentage, the maximum pressure is less and the explosion takes place at a slower rate. This, however, does not apply if obstacles are introduced which materially alter the configuration, nor to two vessels communicating with one another through a small aperture. If ignition takes place in one of the two vessels, the pressure in the second may rise to much more than 7 or 8 atmospheres. In some cases the pressure in the second vessel was found to rise to as much as 12 atmospheres.

This phenomenon has an important bearing on the design of enclosed apparatus for mining purposes. It shows that, under all circumstances, apparatus enclosed in several separate compartments communicating with one another through small apertures must be avoided. At first sight the statement might seem paradoxical that the more gas-tight the lid of such a case fits the greater is the danger if an explosion does occur inside. Tests on a case containing a switch and fuse enclosed in separate compartments with small holes for the electrical connections between the two, and on an enclosed three-phase motor with slip rings enclosed in a separate casing outside the bearing have conclusively proved its truth. All the phenomena connected with internal explosions were studied in an extended series of experiments, the results of which may be summarized as follows:—

"1. The maximum pressure developed in a vessel of moderate capacity by an explosion of accumulated firedamp is about 6.5 atmospheres. If in the inside of the vessel small portions are divided off by internal objects, and the compartments thus formed communicate with one another through comparatively long and tortuous passages, some portion of the enclosure may be exposed to a pressure of 8 atmospheres. Moreover, if the interior is partitioned off into large spaces communicating with one another through small apertures, according to the size and number of these compartments internal pressure may be developed which no practicable method of enclosure can be made to resist. In mines of very great depth the internal pressure is proportionally higher.

"2. Small openings, such as narrow gaps or fine slits in the enclosure, are not dangerous. The larger the area of opening, the less effective is the enclosure, and especially so if the aperture does not expose cooling surfaces to the gas in its passage through it. Moreover, it is less effective the nearer the point of ignition is to the aperture, and the danger increases inversely with explosiveness of the gas. An enclosure which is not gas-tight, or one with openings, is generally safe if the pressure of the ignited gas rises to 1.1 atmosphere or more before flames are expelled."

It was found in the experiments on motors that the rotation of the rotors modified considerably the effects produced. The rotation appears to increase both the pressure and the rapidity of the explosion. Although, then, an enclosing cover with aperture in it may, under certain circumstances, be an effective protection, it cannot be relied on in every case, as its efficiency depends on the composition of the gas, the position of the point of ignition relatively to the aperture, and the state of motion of the rotating parts—all of which, and particularly the last factor, may influence the effect of an explosion in a manner which cannot be determined *a priori*. Under the most favorable circumstances, moreover, the maximum safe area of the openings is small, so that the motor would have to be designed practically with the characteristics of a totally enclosed motor.

To increase the effectiveness of this method of protection, labyrinth enclosure was proposed. This consisted of two or more perforated covers placed one in front of another with the apertures in adjacent covers staggered. It was hoped that some of the heat would be extracted from the gases by the metal covers if the gases were forced to pass some distance over the covers in passing from one opening to the next. Although the size of the openings could be made much larger than in the case of the single cover, it was found that the results of an internal explosion still depended on the same factors, and this method of protection had to be discarded as unreliable. Similar results were found to occur also with the use of tubes in front of the openings.

A series of experiments was carried out to test the efficacy of enclosing with wire gauze, to combine the advantages of a ventilated motor with a reliable flame-proof protection. As in the case of covers with apertures, it was found that the protection depends on the position of the point of ignition of the gas, and is also influenced by the configuration of the internal parts and the state of motion of the rotating parts. The effects of the position of the points of ignition, however, were found to be entirely the reverse of the effects in the case of the enclosure with aperture. Enclosure in wire gauze is a reliable means of protection and can safely be adopted when suitably applied. The protective power of gauze, however, is destroyed by very slight injury, and in addition to using a double layer of gauze some further mechanical safeguard must be provided. One of its most serious disadvantages was found to be the burning of the firedamp within the enclosure already mentioned.

"From the observed fact that slits or gaps of not more than 0.5 millimetre width and about 50 millimetres depth are not sources of danger, finally a form of protection was devised which embraces all the advantages of gauze without its

defects. It is the so-called 'plate' protection. It possesses mechanical strength, permits of ventilation, prevents an explosion by cooling the issuing gases, and is not damaged by after burning should this phenomenon take place. It consists of a series of plates, usually 0.5 millimetre thick and 50 millimetres deep, placed side by side at a distance of 0.5 millimetre from one another in openings of the motor or apparatus casing. These plates are usually in the form of rings or hollow squares, but they can be any shape or size. Any number can be used, according to the amount of ventilation required, and the protection secured is independent of the position of the point of ignition, the relative volume of the containing vessel to the area of opening, and of the composition of the gas.

"So far as the total enclosure is concerned, this method of protection is mainly available in cases where internal ventilation is not essential in order to carry off the heat generated in the apparatus. Apparatus or machinery in which heat is generated is, generally speaking, therefore not suitable to receive this method of protection. In order to be effective, the complete enclosure has to be made very strong indeed, entailing considerable weight and initial cost. On the other hand, this method of protection provides a safeguard against external mechanical injury as well as against internal explosion, and it must be remembered that it is almost a practical impossibility to make any enclosure so perfectly gas proof as to entirely prevent an explosive mixture collecting in the interior, unless it is absolutely physically enclosed (as by soldering or welding). This method of enclosure is therefore mainly applicable to switchgear, junction boxes, and very small motors."

COAL AND IRON RESOURCES OF THE UNITED STATES.

AN ESTIMATE OF THE TONNAGE OF COAL AND IRON NOW AVAILABLE AND OF THE PROBABLE LIFE OF THE EXISTING RESERVES.

M. R. Campbell, E. W. Parker, C. W. Hayes—American Institute of Mining Engineers.

TWO papers prepared by experts the United States Geological Survey and read at the Spring meeting of the American Institute of Mining Engineers give what may be taken as the most trustworthy estimates available of the coal and iron resources of the country and the probable life of the existing reserves. The following abstract of the papers is taken from the *Bulletin* of the Institute for April. Many valuable data have necessarily been omitted from this brief review, which presents only the main points of the discussions and the conclusions as to the probable duration of the supplies of the two materials.

Dealing first with the coal resources, Messrs. Campbell and Parker give the area underlain by workable coal beds in the United States, according to the estimates prepared by the United States Geological Survey, as 496,776 square miles. "Of this total area, 480 square miles contain the entire anthracite coal fields of Pennsylvania. The bituminous coal fields are estimated to be contained in areas aggregating 250,051 square miles. The grade of coal between bituminous and lignite, and which is designated by the Geological Survey as 'subbituminous' is estimated to be contained within areas aggregating 97,636 square miles, while the areas containing lignite aggregate 148,609 square miles."

For the sake of convenience in classification, the coal fields are divided into six main provinces, details of which are given in the footnote to Table I opposite. During the last few years the Survey geologists have made careful estimates in each of these provinces of the quantity of coal contained in the beds when mining first began, the amount easily available and the amount unavailable under present mining and market conditions or available only with extreme difficulty. The areas of the different provinces and

the amount of coal contained in them when mining first began are shown in Table I.

"It is estimated that for every ton of coal mined and sold half a ton is lost or wasted, so that the total production of

TABLE I.—TONNAGE (SHORT TONS) BY PROVINCES AND ACCESSIBILITY.

Province.	Area.	Original Coal-Supply.		
		Amount Easily Accessible.	Amount Accessible with Difficulty.	Total.
	Sq. Miles.	Tons.	Tons.	Tons.
1. Eastern	70,022	555,634,000,000	8,000,000,000	563,634,000,000
2. Interior	144,664	406,667,000,000	91,000,000,000	497,667,000,000
3. Gulf	84,300	13,045,000,000	10,045,000,000	23,090,000,000
4. Northern or Great Plains	103,564	521,793,000,000	459,000,000,000	980,793,000,000
5. Rocky Mountain	92,396	414,740,000,000	574,280,000,000	989,020,000,000
6. Pacific Coast	1,830	11,100,000,000	11,900,000,000	22,000,000,000
Total	496,776	1,922,979,000,000	1,153,225,000,000	3,076,204,000,000

1. Anthracite and bituminous fields of Pennsylvania, Ohio, Virginia, Kentucky, Tennessee, Georgia, Alabama, and North Carolina. 3. Bituminous fields of Michigan, Illinois, Indiana, Kentucky, Iowa, Kansas, Missouri, Oklahoma, Arkansas, and Texas. 3. Lignite areas of Alabama, Mississippi, Louisiana, Arkansas, and Texas. 4. Lignite and sub-bituminous areas of North and South Dakota, eastern Montana, and northeastern Wyoming. 5. Bituminous and sub-bituminous areas of western Montana and western Wyoming, Colorado, Utah, and New Mexico. 6. The areas of Washington, Oregon, and California.

The distribution of this original supply of coal, according to grades and accessibility, is shown in Table II. The derivation of the total of $1,392,979,000,000 tons as the quantity of coal originally easily accessible and available is explained by the fact that the quantity given as easily accessible includes the lignites and sub-bituminous coals of the western states, of which approximately 530,000,000,000 tons, while easily accessible, cannot be considered available under present conditions, or those which may be anticipated in the near future.

6,865,097,567 short tons to the close of 1907 represents an exhaustion of 10,200,000,000 tons, or 0.3 per cent. of the total original supply, or 0.7 per cent. of the coal which is easily accessible and available under present conditions. The total supply of easily accessible and now available coal left in the ground at the close of 1907 was 1,382,780,000,000 short tons."

From a table showing the production of coal annually from 1846 to 1907 and also the average annual production by progressive decades for the same length of time, it is calculated that the average

TABLE II.—TONNAGE (SHORT TONS) BY GRADES OF COAL AND ACCESSIBILITY.

Kind of Coal.	Area.	Original Coal-Supply.		
		Amount Easily Accessible.	Amount Accessible with Difficulty.	Easily Accessible and Available.
	Sq. Miles.	Tons.	Tons.	Tons.
Anthracite and bituminous	250,531	1,176,727,000,000	505,730,000,000	1,176,727,000,000
Sub-bituminous	97,636	356,707,000,000	293,450,000,000	216,252,000,000
Lignite	148,609	389,545,000,000	354,045,000,000	
Total	496,776	1,922,979,000,000	1,153,225,000,000	1,392,979,000,000

"Up to the close of 1845 the total production of coal in the United States was 27,677,214 short tons, and since that time the drain on the supply has practically doubled with each decade. The total production to 1845 and decennially since that time was:

	Short Tons.
Up to 1845	27,677,214
1846—1855	83,417,827
1856—1865	173,795,014
1866—1875	419,425,104
1876—1885	847,760,319
1886—1895	1,586,098,641
1896—1905	2,832,402,746
1906—1907	894,520,702
Total	6,865,097,567

annual increase in coal production is 7.36 per cent. For the last five progressive decades the rate of increase would be above the average. "The assumption that a constant output has been reached would be utterly unwarranted. On the other hand, the adoption of the flat rate of annual increase of 7.36 per cent. would involve the improbable assumption that the marvellous record of the past and present will be maintained in the future, and that the production will continue approximately to double every decade. Using the waste allowance, on

the basis of this constant rate of increase of production, the 1,382,780,000,000 tons available at the close of 1907 would be exhausted in 107 years, or by 2015. Against the use of the flat rate of increase it may well be contended that just as the rate of increase in population tends to diminish, so this rapid increase in per capita consumption of coal cannot persist, and a constant annual production will be reached. However, the figures set 50 years ago by statisticians for the probable constant annual production of coal in England have already been exceeded by more than 160 per cent."

Probably the best use of the data available has been made by Henry Gannett in an estimate based upon a decreasing rate of increase calculated from 20-year averages of production. The result obtained by this method is that the easily accessible and available coal will be exhausted about the year 2027, and all coal by the middle of that century. It must be remembered, however, that with so many indeterminate factors whose importance is realized but cannot be measured, for example, the development of an export trade, better utilization of coal in the industries, reduction of waste in mining, increased utilization of water power, and the operation of the ordinary economic laws, prophecy must possess a questionable value.

Mr. Hayes divides the iron ores of the country into two classes, those available and those not available. "This classification is in large measure arbitrary, and it is evident that it will vary from time to time. In the available class are placed those ores which can be worked at a profit under conditions essentially as they exist at present. Since it depends wholly on the question of costs, the various factors which affect cost will determine the classification of any particular deposit."

The known ore deposits are discussed by groups, based on distribution and kind. These groups are the following: 1. Lake Superior ores. 2. Adirondack ores. 3. Clinton ores. 4. Appalachian metamorphic ores. 5. Appalachian brown ores. 6. Appalachian carbonate ores. 7. West Tennessee brown ores. 8. East Texas brown ores. 9. Ozark ores. 10.

TABLE III.—ESTIMATES OF IRON-ORE SUPPLIE OF THE UNITED STATES IN THOUSANDS OF LONG TONS.

Commercial Districts.	States.	Magnetite Ores. Non-Titaniferous. A.	Non-Titaniferous. B.	Titaniferous. A.	Titaniferous. B.	Hematite Ores. Specular and Red. A.	Specular and Red. B.	Clinton. A.	Clinton. B.	Brown Ores. A.	Brown Ores. B.	Carbonate Ores. A.	Carbonate Ores. B.	Total Supplies. A. Available	Total Supplies. B. Not Available.
1. Northeastern		160,000	111,500	90,000	100,000	2,000	2,000	35,000	620,000	11,000	13,500	.....	248,000	298,000	1,095,000
2. Southeastern		12,500*a*	23,000	.....	.....	8,000	53,000	463,540	970,500	54,400	168,000	.....	62,000	538,440	1,276,500
3. Lake Superior		.....	4,500,000	.....	25,000	3,500,000	67,475,000	10,000	30,000	.....	.....	.....	.....	3,510,000	72,030,000
4. Mississippi Valley		.....	.....	.....	.....	15,000	10,000	.....	.....	300,000	560,000	.....	.....	315,000	570,000
5. Rocky Mountain		51,485*a*	115,440*b*	....	1,500	4,275	2,100	.....	.....	2,000	1,625	.....	.....	57,760	120,665
6. Pacific Slope		68,950*a*	11,800	.....	2,000	.....	10,000	.....	.....	.....	105	.....	.....	68,950	23,905
Totals		292,935	4,761,740	90,000	128,500	3,529,275	67,552,100	508,540	1,620,500	367,400	743,230	.....	310,000	4,788,150	75,116,070

1. Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Ohio. 2. Virginia, West Virginia, Eastern Kentucky, North Carolina, South Carolina, Georgia, Alabama, East Tennessee. 3. Michigan, Minnesota, Wisconsin. 4. Northwest Alabama, West Tennessee, West Kentucky, Iowa, Missouri, Arkansas, East Texas. 5. Montana, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico, West Texas, Arizona. 6. Washington, Oregon, California.

a Includes some hematite.

b Includes some titaniferous magnetite.

Rocky Mountain metamorphic ores. 11. Igneous contact ores. The estimates given in more or less detail under these 11 groups are combined in Table III, under five commercial districts.

TABLE IV. PRODUCTION OF IRON ORE IN THE UNITED STATES BY DECADES, 1870 TO 1909.

Decade.	Production, Long tons.	Increase, Per Cent.
1870—1879.....	43,770,527	.....
1880—1889.....	91,043,854	108.
1890—1899.....	163,989,193	80.1
1900—1909 about.....	392,000,000	138.

The production of iron ore in the United States by decades, from 1870 to 1909, is given in Table IV. "If the average rate of increase by decades, 108.7 per cent, should be continued, it would require the production in the next three decades of 6,088,000,000 tons. But the ore supply now available in the United States is estimated at 4,786,000,000 tons, which is only 78 per cent. of the amount needed on this assumption. It is evident therefore that the present average rate of increase in production of high-grade ores cannot continue even for the next 30 years, and that before 1940 the production must already have reached a maximum and begun to decline, and a very large use must be made of low-grade ores not now classed as available. The second condition, with its consequently greatly increased cost of iron, is the only thing which can prevent a decline in the iron-industry, measured by the amount of pig iron produced, within the next 30 years, unless there is in the meantime very greatly increased importation of foreign ores."

THE TESTING OF PROTECTIVE COATINGS FOR IRON AND STEEL.

A DISCUSSION OF THE VALUE OF PHYSICAL TESTS FOR PAINTS EMPLOYED TO PROTECT IRON AND STEEL FROM EXTERNAL INFLUENCES.

J. Cruickshank Smith—Iron and Steel Institute.

THE essential qualities of satisfactory protective coatings for preventing the corrosion of iron and steel were briefly outlined by Dr. William H. Walker in the May number of THE ENGINEERING MAGAZINE. A more extended discussion of the subject of corrosion is contained in a paper read by the same author at the recent meeting of the Iron and Steel Institute. Jointly with the latter was discussed a paper by J. Cruikshank Smith, on the value of physical tests in the selection and testing of protective coatings, which gives a brief review of technical methods of investigating the physical properties of paints. The latter are, in Mr. Smith's opinion, of fully as much importance as their chemical properties. A short abstract of this paper is made from a reprint in the *Iron and Coal Trades Review* for May 14.

The increased attention which has been devoted during recent years to the physical and mechanical properties of paints, varnishes and other protective materials has been largely due to the growing appreciation, on the part of chemists and engineers, of the fact that in actual service, and under the conditions of prolonged exposure to the atmosphere, moisture, etc., the life of protective coatings depends as much on physical laws as on chemical ones; and, further, that the physical state or condition of a protective coating has an important bearing on its liability to chemical influences, both external and internal. Protective coatings consist as a rule of a pigmentary portion and a fluid medium or vehicle. Pigments are themselves invariably defined and valued in terms of physical properties, opacity, insolubility and degree of crystalline structure. The fluid vehicle after drying presents certain mechanical features as to elasticity, hardness, etc., which determine its value as a paint material. When it is considered that the cost of maintenance of a structure depends on the capacity of a paint film, usually not more than 1/200 of an inch thick, to expand and contract without breaking with the expansion and contraction of the structure itself, to maintain a hard and impervious surface, to resist the solvent action of rain water and chemical impurities in the atmosphere, it will readily be granted that the physical properties of paint films are of pre-eminent impor-

tance in determining the selection of protective materials.

The physical tests which may be employed as a guide in selecting protective coatings are of two kinds: (1) those applicable to the paint itself and (2) those applicable to the film produced by the drying of the paint. Those in the first class depend on the following principles:—

(a) The pigment and vehicle should be properly proportioned in order to ensure efficient application and the minimum of free oil space in the dry film.—The physical property which underlies the question of correct consistency of the paint is that of viscosity, and on the viscosity depends to a great extent the efficiency with which the paint can be applied. If the viscosity be too high, the paint film will be too thick, and will dry unevenly and imperfectly. If the viscosity be too low, the film will be too thin and the paint will have a tendency to run. No method has yet been elaborated by which the correct consistency of a protective coating can be accurately determined before use. The user can protect himself only by specifying that the consistency of the paint shall be such as to enable a film of a given thickness to be produced under stated conditions.

The question of free oil space in a paint film is an extremely important one. The real protective agent seems to be the pigment, the fluid vehicle acting merely as a binding or cementing medium. It has been proved that the smaller the amount of free oil space the more impervious to moisture, and, as a rule, the more durable, will the film be. In selecting a protective paint a careful examination of the film should be made with the microscope to determine the relative areas occupied by solid pigment and transparent vehicle.

(b) The size of the pigmentary particles should be small and uniform.—The actual measurement of the small particles of pigment is a matter requiring some experience and manipulative skill, but such measurements cannot be neglected in the physical testing of protective coatings. In general it may be said that the pigment in a paint may be considered finely ground when the largest particles do not exceed 0.001 inch in diameter. In a paint which has proved thoroughly satisfactory under service conditions the largest particles were of this size, the smallest 0.0002 inch in diameter, and the average size of the particles was 0.0004 inch. A paint of similar composition but which proved unsatisfactory in service had particles as large as 0.018 inch in diameter, the finest being 0.0002 inch and the average 0.008 inch.

(c) The pigment and the vehicle should possess the minimum tendency to separate from each other.—Theoretically a paint consisting of pigment and vehicle should be in such a state that it flows like a homogeneous liquid without separation into its component parts, and it is within the power of the manufacturer to approximate to this ideal condition. A simple test can be applied to determine whether separation will occur. The paint in a condition ready for use is placed on a piece of sheet glass, which is then stood vertically for one hour at a temperature of 100 degrees F. No separation of the pigment and vehicle should be observable at the end of that time, even though, to make the test more severe, the paint be thinned with raw linseed oil.

(d) Accelerated tests.—To determine with perfect accuracy whether a material under test will behave satisfactorily under service conditions would require a whole series of long and laborious exposure tests, impossible under commercial conditions. It is possible, however, to arrive at a satisfactory conclusion by exposing the paint to severe conditions for a short space of time and examining the films so produced in order to see whether they are free from the defects which one would expect to find in them after long exposure to milder conditions.

The physical tests applicable to the film are as follows:—

(a) Determination of the thickness and uniformity of the film.—The actual utility of the film will depend greatly on the thickness at the thinnest point and it is, therefore, of importance to determine whether the film produced by a pro-

tective coating is likely to be uneven. The average thickness of the film can be determined readily by calipering two pieces of glass with a film of paint between them. Variation in the thickness of the film at different points can be detected with the microscope. Inequalities of thickness are due largely to variations in the size of the pigmentary particles. If the latter factor is properly adjusted a film of uniform thickness is easily obtained.

(b) Strength of film as determined by breaking machine.—It is now possible to make accurate determinations of the strength of films by means of an ingenious instrument devised about two years ago by Mr. R. S. Perry. Considerable experimental work has been done with the "filmometer" in determining the pressure necessary to rupture various paint films of known thickness, but the tests are not yet far enough advanced to enable one to predict from them with any certainty what relation exists between them and durability in service. Much valuable information on the effect of age on the strength and elasticity of a paint may be expected in due time.

(c) Elasticity of film.—This factor also can be measured by the filmometer, the application of which to technical testing may be expected in the near future.

(d) Permeability of paint films by vapors and gases.—It has been abundantly proved that all paint films are permeable by moisture and gases. They differ, however, in the degree of permeability, and the less pervious they are the better will they effect their purpose of protection. A method for determining the relative permeability of films has been devised by the Paint Manufacturers' Association of the United States.

(e) Hardness of surface of film.—Hardness is an important factor, since many protective coatings have to resist surface blows, abrasions, etc. It can be measured in terms of a defining standard by means of an instrument devised by Bailie and Laurie and described in the *Journal* of the Royal Scottish Society of Arts for July, 1906.

THE PURIFICATION OF WATER BY OZONE.

A DESCRIPTION OF A SUCCESSFUL INSTALLATION IN THE CITY OF CHARTRES, FRANCE.

M. L. Borne—Société des Ingenieurs Civils de France.

THE problem of pure water supply has been solved at Chartres, France, a city of about 23,000 inhabitants, by the addition to the existing works of apparatus for treatment of the water by ozone. The waters of the River Eure, from which the supply for Chartres is drawn, contain numerous bacteria, many of them of a pathogenic character. These are entirely removed by the ozone treatment. The apparatus installed, which has a capacity of about 6,000 cubic metres (1,600,000 gallons) per day, represents an outlay of only $70,000. The low first cost of this plant and its complete success are evidence of the economy and efficiency of the process. We take a few details of the practice at Chartres from a recent paper by M. L. Borne, read before the Société des Ingenieurs Civils de France.

Power is supplied by two 40 horse power steam engines, one of which is held in reserve. Each engine drives an alternator. The water is raised to the filter plant by means of a centrifugal pump. The apparatus for the production of the ozone is wholly enclosed in glass. It consists of two hollow metallic electrodes, separated by glass and cooled by jets of water, which receive the current, at 500 periods and 15,000 volts, from the generator. The ozone is produced by the sparkling between the electrodes. Cooled and dried air is supplied to the case containing the ozone apparatus by means of a fan. The ozonated air is led to a Gay-Lussac tower which receives at the top the water to be sterilized. The tower has two compartments, each 1½ by 7 metres, filled with crushed flint to a depth of 4½ metres.

The sterilization of 1 cubic metre, (265 gallons) of water requires 370 litres of air containing 5/6 milligram of ozone per litre. A little more than 2 grams of ozone are required, therefore, for each cubic metre of Eure water treated. The amount of ozone required varies, of course, with the amount of organic matter in the water. That of the Chartres supply contains about 3 milligrams of organic matter per litre.

The clarifying plant comprises ten sand filters, 6 by 7 metres, with a sand bed 1 metre thick supported on iron grills which allow the escape of the water and facilitate mechanical cleaning of the filters. The capacity of these filters is about 15 to 20 cubic metres per square metre of filter surface per day. Before reaching the sand filters, the water passes through biological filters filled with coke, two of which precede each sand filter and are operated alternately. In them the water is subjected to an oxidizing action, and about 80 per cent. of the bacteria are removed.

The filter plant with piping and appliances for cleaning cost 90,000 francs and the building containing the filters, 60,000 francs. The first cost was therefore 25 francs per cubic metre of water treated per day. The ozone installation cost 110,000 francs, inclusive of the sterilizing tower. Adding to these amounts the cost of the land, the electric plant and the piping connecting the two plants, the total cost of the water treatment works was 350,000 francs for a capacity of 6,000 cubic metres per day, a first cost of 58 francs per cubic metre. Excluding the cost of the land this is reduced to 50 francs per cubic metre.

Purification plants embodying in their design all modern improvements are higher in first cost than those of the old types, but the cost of ozone treatment increases only very slightly the unit cost of operation. Allowing 5 per cent. interest on capital and a plant life of forty years, the purification of water containing not more than 1 milligram of organic matter per litre varies between 0.025 and 0.013 francs per cubic metre when ozone sterilization is used, according to whether clarification of the water is necessary. The cost of filtration without sterilization varies between 0.010 and 0.015 francs per cubic metre.

THE PROPOSED NATIONAL SHIP CANAL IN SCOTLAND.

AN OUTLINE OF THE PROJECT FOR A DEEP-WATER CANAL BETWEEN THE FIRTH OF FORTH AND THE FIRTH OF CLYDE.

Engineering.

THE proposal to cut a ship canal from the North Sea to the Atlantic sea board of Scotland, of suitable depth and width to accommodate the largest warships, has again been brought before the Royal Commission on Canals and Waterways. There exist at present two canals across Scotland, one of which is used only by barges. The other is owned by the Government but will accommodate vessels of only 17 feet draught. The agitation for a deep-water canal has received a great impetus since the development of the naval policy of Germany, and it is not improbable that the Government may be forced by the present state of the national temper to authorize its immediate construction. We abstract the following brief review of the project from an editorial discussion in *Engineering* for April 23.

The construction of a naval base at Rosyth, on the Firth of Forth, is urged as an important reason for building a canal of adequate size to meet the prospective needs of a war fleet. Of the strategic advantage of such a waterway in the concentration of a fleet in the North Sea there can be no question. The passage around the north of Scotland is difficult and dangerous, and the junction of the Atlantic Fleet, located in the English Channel, with the Home Fleet, located at the Nore and in the north, might be a difficult operation with

the existence in the North Sea of an opposing fleet superior to either. The canal would undoubtedly add materially to the mobility of the fleet.

The location of the naval base at Rosyth, further inland than the Forth bridge, was opposed on the ground that the destruction of the latter might cause serious obstacles to the movement of a fleet from Rosyth. While the water at the Forth bridge is so deep that the debris would not be likely wholly to obstruct navigation, there may be justification for the suggestion that an emergency canal should be constructed to the north of the bridge. This canal, which would need to be only two miles long, would be supplementary to the ship canal across Scotland. The latter would incidentally meet the same difficulty, but its main function is the connection of the North Sea with the Atlantic.

An equally important advantage claimed for the canal is that it would place at the service of the Navy authorities the immense naval construction facilities of the Clyde and the West Coast generally. The present scheme for the equipment of Rosyth contemplates the building of one graving dock, in addition to the large entrance lock which will serve the same purpose as a dry dock, and the installation of machine shops of considerable size. The whole plant, however, will be no more extensive than will be required for the routine overhaul of ships during peace time. It will be entirely inadequate for the repair and reconstruction of ships severely damaged in war. Indeed, the equipment of Rosyth for undertaking such extraordinary work must be condemned from the point of view of national economics. The cost would be immensely greater than the expense of cutting a ship canal, and it is a subject for serious reflection whether the canal would not yield a much higher advantage in war time than an elaborate establishment at Rosyth, which would be more or less non-productive in peace time.

The canal would also be of importance from the point of view of commerce. The distance by water from Glasgow to Edinburgh by the north route is 500 miles, and by the south route, 900 miles. By canal it would be only 65 miles. Some of the other reductions in distance are as follows:

	Miles.
London to Belfast	100
London to Glasgow	271
Hull to Liverpool	264
Hull to Belfast	298
Hull to Glasgow	626
Newcastle, Shields, &c. to Belfast	298
Newcastle, Shields, &c. to Liverpool	333
Newcastle, Shields, &c. to Glasgow	449
Aberdeen to Glasgow	341
Aberdeen to Liverpool	218
Aberdeen to Irish Ports	300
Dundee to Glasgow	434
Dundee to Liverpool	318
Dundee to Belfast, &c.	204
Hamburg to Glasgow	487
Copenhagen to Glasgow	487

"For coastwise traffic, the distance from Glasgow to harbours south of the Forth on the coast of Scotland and England would be nearly 400 miles less; while to the Skager Rack, for the Baltic ports, the relative distances would be 540 miles by canal, and 780 miles by the Pentland Firth. For west-bound traffic the mileage for shipping from the Forth to ports on the north-west of England and Liverpool would be 275 miles, as against 675 miles; and to Cape Finisterre, 890 miles by the canal, as against 1,065 miles by the English channel. These savings are of great advantage, both east-bound and west-bound, in view of the extensive export of coal from the Forth and Clyde ports, apart altogether from general merchandise. For traffic between the north-west ports of Europe and America, as already indicated, the hazardous nature of navigation round the North of Scotland would favor the canal route. This north-west passage is taken by about 5,000 vessels per annum, representing a tonnage of 4 million tons, so that there are here considerable potentialities for development of canal traffic. Messrs. D. and C. Stevenson, of Edinburgh, who have been consulted in the matter, estimate from Board of Trade returns that there might be available almost at once from 5 to 7 million tons. They consider that in view, not only of the saving in the cost of steaming by using the canal instead of the Northern Sea passage, the reduction in time required for the voyage, and the possible increase in the number of voy-

ages made per annum, with increased profits, there might be justification for an average canal rate of 1s. 6d. per ton. This, they consider, would in the near future yield a revenue sufficient to pay from 2 to 2 1-2 per cent. on the total cost." It is proposed that the Government undertake the work, or, at least, guarantee such a rate of interest as would enable the capital, estimated at about 20 millions sterling, to be publicly subscribed.

"As to the dimensions of the canal there is no room for any difference of opinion. It must be capable of taking the largest of battleships, even when waterlogged, and consequently any depth less than 36 feet would be unsatisfactory. The width at bottom should not be less than 100 feet, and a further disideratum is that there should be a minimum number of locks. Two routes have been suggested. One of these, as shown on the map, follows the line of the present canal and debouches into the River Clyde at Yoker, 3 or 4 miles west of Glasgow." The excavation would be in easy material, but at some points the cutting would be 160 feet deep. The contour of the country, however, is not so favorable to a canal as the Stirling and Lock Lomond route, also shown on the map, which, though longer, would require no locks except at the terminals. The advantage in length of the "high-level" route would be largely nullified by the numerous locks, for which it might be difficult to obtain the necessary water supply, and by the difficult navigation of the narrow and congested part of the River Clyde, between Yoker and the large shipyards.

The route which finds the most favor, and has been strongly advocated by Messrs. Stevenson after a full survey of all possible routes, begins on the Firth, near Grangemouth, extending westward along the valley of the Forth. To within 10 miles of Loch Lomond the contour of the country is particularly favorable to the construction of a canal, but at this point the ground rises to an ultimate height of 260 feet above sea level, dipping again to the level of Loch Lomond, 22 feet above sea level. The distance across this high ground between 50 foot contours is about 8 miles, and between 200 foot contours about 1¾ miles. The excavation would be in the old red sandstone, and, though deep, need not be broad.

From Loch Lomond there are two alternative routes. One is by the valley of the Leven, through Balloch, Alexandria, and Dumbarton, on the Clyde; the other is from Loch Lomond to Loch Long, across the narrow neck of land at Tarbet. The former route has the advantage of length, but it also debouches into the narrow and congested part of the Clyde. Moreover, though 7½ miles shorter than the Tarbet route, the route through the Leven valley would require three or four miles of additional canal. "On the Tarbet route from Loch Lomond the ships would traverse 13½ miles of the loch, which is sufficiently deep for all practical purposes, to Tarbet, where there is only a distance overland of 1¾ miles to Loch Long, with a railway crossing. This ground, however, ascends to a height of 130 feet above the mean sea level, but as soon as this is traversed vessels can steam full speed down Loch Long to the Clyde and then to the sea. Loch Lomond would be the summit level, and as it has a water area of 21,000 acres, and a gathering area of 290 square miles, there is an inexhaustible supply for the locks at each end. The difference in the level is 13 feet and 17 feet above high-water level at the Forth and the Clyde respectively.

"The total distance from the Forth to the Firth of Clyde at the mouth of Loch Long is 68½ statute miles, but of this distance 28½ miles is made up by Loch Lomond and Loch Long, so that the length of cutting would be 40 miles, in addition to the deepening of the Forth from opposite Grangemouth to the canal lock. The total distance from Grangemouth to about the same point in the Firth of Clyde by the 'high-level' route, debouching at Yoker, is 50½ statute miles, which gives an advantage of 18 miles; but owing to the crowded channel of the Clyde from Yoker, about 20 miles from the Firth, the time occupied, estimating 6 knots for the canal and river,

and 12 knots for open water, and 20 minutes for each lock, would be 8¼ hours by the Loch Lomond route, and 11¾ hours by the other route.

"The proposal is to make the locks at Grangemouth and at Loch Long 900 feet long and 100 feet wide, with small locks alongside, 450 feet long by 45 feet wide. The Caledonian main line crosses the route at Stirling, in addition to four local or branch lines, while many public roads also pass over the proposed route. In this respect the Loch Lomond route has probably an advantage. Originally it was proposed to have swing-bridges, but in order to minimise possible objection, it has been decided that high-level bridges should be constructed for railways. This increases the capital cost by a million sterling. It is estimated that for a canal with 36 feet draught of water the total cost would be 20 millions sterling. This, however, might be reduced if the level of Loch Lomond were raised by the construction of a dam at Balloch, a point which might further be achieved by the formation there of a deeper lock than at Tarbet, and the canalisation of the valley of the Leven. These figures might be somewhat modified by a complete survey, but a good case has been made for the full consideration of the scheme, especially in the light of recent naval developments."

THE RELIABILITY OF LARGE GAS ENGINES.

A SUGGESTION OF ITS IMPROVEMENT BY PRE-COMPRESSION OF THE CHARGE AND THE USE OF EXHAUST GAS TURBINES.

Felix Langen—Zeitschrift für das gesamte Turbinenwesen.

RECENT practice in the design of large gas engines has shown a strong tendency towards the reduction of the size of cylinders to as small dimensions as practicable. This has been due to the appreciation of two facts, the practical difficulty of building large-diameter cylinders strong enough to withstand the high stresses to which they are exposed and at the same time free from the danger of rupture under unequal expansions, and the fact that increase in cylinder and other dimensions requires an increased expenditure in metal and workmanship in greater proportion than increase of power obtained. Herr Felix Langen, writing in the *Zeitschrift für das gesamte Turbinenwesen* for April 30, emphasizes the fact that the large size of cylinders, pistons and valves has been largely responsible for the lack of reliability which has prevented the rapid general adoption of the large gas engine. He suggests as a means of reducing cylinder dimensions the pre-compression of the charge and the use of gas turbines for utilizing the power in the exhaust gases.

The desideratum is the reduction of cylinder dimensions relatively to the volume of the charge at atmospheric pressure. It is apparent that the cylinder can be reduced in size proportionately to the compression of the mixture above atmospheric pressure before it reaches the inlet valve. Against the saving in cylinder metal and workmanship would have to be set the cost of the large charging pump. There would be a drop in efficiency, due to the power demands of the pump and the imperfect expansion of the gas in the engine cylinder.

Experience with turbine machinery has shown that rotary machines like the fan, centrifugal pump and steam turbine are best suited to large volumes at comparatively low pressure. On the other hand, the best field for the piston machine, whether pump or motor, is for small volumes at high pressure. The successful combination of the low-pressure steam turbine with the high-pressure reciprocating engine suggests that a similar combination could be made effectively with gas machines also. The operation would be as follows: the charge would be compressed by a high-pressure fan or turbo-compressor. Proportionately to the increase in pressure the suction volume can be reduced, and in a less

proportion the cylinder dimensions. At four atmospheres, the suction volume could be reduced to one-quarter and the cylinder dimensions to one-half of those necessary with the charge at atmospheric pressure. A pre-compression of a single metre of water, such as could be secured with a high-pressure fan, could be applied with advantage to the charge used in existing engines. An overload capacity of at least 10 per cent. could easily be obtained by this means. For effective reduction of cylinder dimensions, however, a compression of several atmospheres is necessary. This can be obtained with turbo-compressors of the Rateau type which have already given pressures up to eight atmospheres. The four atmospheres which would be required for the compression of the charge could be obtained with a fairly small three-stage machine. By cooling the mixture between stages and also before it enters the cylinder, compression in the latter may be materially increased without danger of pre-ignition.

Without pre-compression the temperature of the exhaust gases at the end of the working stroke is about 1,000 degrees absolute, and the pressure about three atmospheres absolute. With pre-compression the final pressure would be about 12 atmospheres. The efficiency of the engine would be the same in each case, since the pressure ratios and temperature drop would be identical. Only the power consumption of the compressor would affect the efficiency, and of this a part would be returned in work on the piston during the suction stroke. There is no reason why a reliable turbine could not be built to utilize the energy in the exhaust gases, which would be at a temperature of 1,000 degrees absolute and 12 atmospheres pressure. Expansion to atmospheric pressure would reduce the temperature to 490 degrees absolute. Friction, however, would raise it to about 700 degrees absolute, or around 430 degrees C. The speed of the gases would be about 1,000 metres per second. This would demand in a single-stage turbine a rotor of 500 mm. diameter and a speed of 12,500 revolutions per minute.

Herr Langen demonstrates that the turbine would deliver more than enough power to run the compressor. There would be no difficulty in direct connecting turbine and compressor. They might even be built as one unit. If the power of the turbine is in excess of that used to compress the charge, the extra power might be utilized to drive a high-speed air compressor. If a reciprocating compressor is driven from the engine, the air for this could be pre-compressed and a reduction of cylinder dimensions effected. In general, however, it would be wise to apply the power of the turbine only to the compression of the charge. By pre-compression and the use of an exhaust gas turbine, the cost of a gas engine in materials and labor may be reduced more than five times the cost of the combined compressor and turbine installation.

MARINE INTERNAL-COMBUSTION ENGINES.

SOME CONSIDERATIONS ON THEIR WEIGHT AND SPACE REQUIREMENTS AS COMPARED WITH STEAM EQUIPMENT.

H. C. Anstey—Institution of Naval Architects.

THE principal advantages claimed for the internal-combustion engine are economy in fuel, weight and space. There are abundant data to substantiate the claim that the least economical of internal-combustion engines is more economical in fuel than the best steam engine; on this fact most of the discussions of the possibility of applying combustion motors on a large scale to marine propulsion have been based. Concerning the economy of weight and space which may be expected in large installations, however, very little definite information is available. Mr. H. C. Anstey, who read a paper on the subject at the recent meeting of the Institution of Naval Architects, has done a distinct

service in presenting in brief form the considerations on which an estimate can be based. The paper is printed in full in *Engineering* for April 9; the following abstract summarizes the main points of Mr. Anstey's discussion.

"Some very remarkable results have been obtained with small petrol engines in respect to power developed on a given weight, but it is to be remembered that this extreme lightness is due principally to two causes, viz.:—(1) A high speed of revolution, and (2) the use of special materials of construction. No part of the extreme lightness is due directly to the engine being of the explosive type. There are certain conditions incidental to the internal-combustion engine which make higher speeds of revolution possible than are possible or advisable with a reciprocating steam engine of similar size. To arrive at a proper sense of proportion on the question of weight and space, it is desirable to examine it on broad mechanical principles. Of the factors which together make up the horse-power of an engine, the only one which in an engine of given power may be altered without affecting its weight is the number of revolutions, subject always to the consideration that the inertia forces due to the speed are not such as to require special strength and weight of parts and foundations.

"From the factors in the formula for horse-power, it follows that if we assume piston area, stroke, and number of revolutions to be constant, the power is proportional to the mean pressure. The weight, but in the internal-combustion tional to the maximum pressure for which the engine has to be designed, and the horse-power per ton is, therefore, proportional to the ratio, mean to maximum. In considering what this ratio is in a marine steam engine we are faced with the difficulty that the power is divided between several cylinders, each having a different ratio of maximum to mean, but for purposes of comparison we shall probably not be far wrong if we assume that the whole of the expansion is carried out in the low-pressure cylinder which develops the whole power and is credited with the whole of the weight. Under this assumption the maximum pressure will be, say 250 pounds and the mean 50 pounds, giving a ratio of maximum to mean of 5. This ratio will vary with the ratio of expansion, and will be generally higher in the merchant service than in naval practice. In internal-combustion engines, in spite of variety of type, there is not very great variation in this ratio. In the engine with which the author is best acquainted it is approximately 4. In petrol engines it will be rather less, and in engines using a high compression it will be somewhat more. Taking the ratio as 4, it must be corrected for the cycle employed, and as the internal-combustion engine has in most types only one working stroke in four, the ratio must be multiplied by four, and the comparative figures will then be, for the steam engine 5, for the internal combustion engine 16; that is to say, considered from the point of view of pressure alone, the horse-power per ton in an internal combustion engine will be 1/3.2 times that of a steam engine of the same linear dimensions.

"There are, however, certain factors to be considered which will make the comparison more favourable to the internal-combustion engine. First, the items of weight, but in the internal-combustion rectly proportional to the horse-power account for a fair proportion of the total weight, but in the internal-combustion engine the proportion of similar parts will be very much less.

"Taking the three factors, lighter accessories, lighter parts, and higher possible speeds of revolution into consideration, it would appear that the figure 1/3.2, which was arrived at from considerations of maximum and mean pressure alone, can be considerably increased. How much it may be increased is more or less a matter of conjecture, but it will possibly be of the order of 1/1.5 to 1/2.5, so that for engines of the same linear dimensions the horse-power per ton will in the internal combustion engine only be about one-half what it will be in a steam engine.

"So far we have left out of account the question of weight of boilers and

their accessories. These will have a counterpart in the gas producers for the gas engine, but have no equivalent in the oil engine. So far as the gas engine is concerned, the weight and space required for producers is largely dependent upon the type of fuel used and the cleaning arrangements necessary to deal with the gas, and this is too large a subject for the present paper. As the weight of boilers is usually about equal to the weight of engines, it follows from the above conclusion that the horse-power per ton will, for the complete installation, be about equal to that of an oil engine of the same linear dimensions as the steam engine. It is possible that there may be some saving, but it appears certain that if the internal-combustion engine is to develop on lines parallel to that of the steam engine, that is with few cylinders, there will be no very great saving, such as has sometimes been imagined by inference from units, where the speed of revolution is high.

"The permissible speed of revolution can be connected with the diameter of cylinder in the following manner:—The reciprocating weights per square inch of piston increase with the diameter, and are approximately proportional thereto. and it can be shown that for a given piston speed the permissible speed of revolution varies inversely as the diameter. It follows, therefore, that a necessary condition of high speed of revolution and higher power per ton of weight is a small diameter of cylinder.

"The direction then in which light weight is to be sought lies in keeping down the diameter of the cylinder, thus allowing a higher speed of revolution; but for large powers this involves a large number of cylinders. That a larger number of cylinders than usual with steam practice is inevitable is apparent from considerations of uniformity of turning moment, but how far the number can be advisedly increased can only be determined by experience. Up to the present sixteen cylinders have been used on one shaft, and there seems no reason why this number should not be increased by successive steps of four or more cylinders at each step. The powers, however, which have been obtained per cylinder in engines whose design admits of application to propulsion are not large, probably not exceeding 100 horse power, and until the unit is largely increased the very large powers required in many present-day vessels are out of reach of the internal-combustion engine, the immediate application of which would appear to be concerned mainly in the propulsion of boats and small vessels. In powers, say, of 500 horse power on one shaft, it appears reasonable to expect 12 to 15 horse power per ton of machinery weight, and though this is low compared with larger powered engines for naval work, it is higher than the ordinary run of merchant service practice. The figures given above refer to a complete installation of oil engines, without auxiliaries; the weights will be greater with gas engines, for the reasons already given.

"In connection with the use of a large number of cylinders, some reference should be made to the proposals which have been made from time to time for transmitting power from engine to propeller electrically. The problem of electric propulsion is one of great interest, and its adoption in special circumstances may be justified, but it would seem that generally it does not offer sufficient commercial advantages for mercantile work, and on the other hand, for naval work it cannot compete with existing steam machinery in the all-important considerations of weight and space.

"The question of the economical application of the internal-combustion engine to propulsion in large size, whether the economy is viewed from the standpoint of cost, weight, or space, is largely bound up with the problem of making a reliable reversing engine. In small sizes, the familiar devices of reversing propeller or reversing clutch will, no doubt, do all that is required, but few, if any, marine engineers would care to contemplate their adoption in thousands or even several hundreds of horse-power.

"An account of a successful experiment in a reversing engine of 80 brake horse-power of the Hornby type has been given by the author in another place. The

method there described is applicable to larger engines of this type. With such a reversing engine there is a possibility of considerable saving in space over steam machinery, and as compared with mercantile practice, some appreciable saving in weight without reference to saving in quantity of fuel carried. The main claims, however, which the internal-combustion engine has for consideration are in the superior fuel economy and smaller number of men required for working, and these claims are so unquestionable that there appears no reasonable doubt that it must eventually, in a large number of cases, take the place of steam machinery for marine propulsion, as it is now doing on a large scale in stationary land practice.

"The author has endeavored to place the question of weight and space required for internal combustion engines in its true perspective, and although the saving, particularly in space, will in most cases be real, he would repeat that, on the whole, there will be no great saving in weight such as has sometimes been imagined by inference from results obtained in land and marine practice in small units."

UNSOLVED PROBLEMS OF THE AUTOMOBILE.

A SUMMARY OF THE PROBLEMS CONNECTED WITH THE MATERIALS OF CONSTRUCTION, DESIGN, AND POWERING OF MODERN MOTOR VEHICLES.

Colonel H. C. L. Holden—Institution of Civil Engineers.

FOR several years the annual James Forrest lecture before the Institution of Civil Engineers has dealt with the unsolved problems connected with the particular branch of engineering in which the lecturer of the year was especially interested. In accordance with this practice Colonel H. C. L. Holden, who was invited to deliver the James Forrest lecture for 1909, took as the subject of his lecture before the Institution on April 26, the road motors of the present day and some unsolved problems connected with them. The invitation extended to Colonel Holden was the first official recognition by one of the most august engineering societies in the world of automobile engineering as a distinct branch of the profession. The lecture has therefore a special significance. It is given in brief abstract below.

The problems regarding medium and light road motors are similar, and Colonel Holden devoted most of his paper to the latter type, which includes passenger vehicles, light delivery vans, and motor bicycles, tricycles, etc., the speed of which is limited by law to 20 miles per hour. Though by far the greater number of such vehicles are driven by petrol engines, there are others driven by steam, electricity and combined systems; compressed air and liquid air have also been tried but have never passed beyond the experimental stage. It is estimated that, of the 100,000 motor cars and cycles in use in the British Isles, more than 99 per cent. are driven by petrol engines. In spite of the great inherent advantages of the steam engine, steam-driven road motors form so small a portion of the whole as to render it obvious that at present their advantages do not outweigh their disadvantages. For heavier goods and public passenger vehicles they may in time compete with petrol vehicles, but for private motor cars the boiler and burner will always, in Colonel Holden's opinion, handicap the system's other advantages. Electric propulsion would be ideal if a source of electricity were available which would bear comparison with petrol in weight, cost and portability. The generation of electricity direct from the oxidation of coal or other fuel cannot be said to be impossible, and it may be actually within our reach if we only knew how and where to grasp it.

Nearly all the internal-combustion engines in use employ the Beau-de Rochas or four-stroke cycle. Greater uniformity in the turning moment has been secured by having multiple cylin-

ders, and at high speeds of rotation there would not appear to be much room for improvement in this respect. At the same time, individual impulses are not entirely dampened out before they reach the road, and these leave their effect to a certain extent evident on the wearing surface of the tires. It is difficult to see how a more uniform turning moment can be obtained with reciprocating engines. An engine of the rotary or turbine type would be effective, but no successful example at present exists. The moving parts of the engine, and also the explosion pressures on the pistons, can be balanced so perfectly by use of the double-piston type that, if the car is at rest, it is difficult to detect by eye or ear if the engine is running. The turning moment, however, cannot be balanced, and reacts on the whole car when running, especially at full power and slow speed, as when climbing a hill. A more perfect solution may be obtained at some future time, but it would necessitate the employment of an entirely different type of engine and transmission mechanism.

The use of the spray or jet carburettor has now become universal. The carburettor that will supply a constant mixture at constant pressure and temperature under all conditions of running of the engine is one problem which has yet to be solved. When to this has been added some device whereby this constant mixture shall be diluted with air to exactly the correct extent to give perfect combustion on explosion in the cylinder, then, and then only, will perfection in this matter have been reached. The whole question of carburation is very complex, and Colonel Holden regards with satisfaction the fact that it has now been taken up seriously by scientific experimenters.

No universal method of ignition has been arrived at, though electricity in some form or other seems more nearly to approach the ideal than anything else. The electric system of ignition enables the moment of ignition to be varied exactly as required, giving very complete control over the speed and power of the engine within limits. However, these limits constitute the weak points in what might otherwise be a perfect system. Hot as the spark is, it is unable to ignite with readiness mixtures which have more than a certain percentage of air, and the ignition, being so extremely local, prevents the flame in a weak mixture being readily transfused throughout the whole of the charge. Improvements in the original system have been in the direction of substituting mechanical for chemical means of production of the current. Owing to the fact that a slight difference in the mixture or in the amount of compression entails an alteration in the time when the charge must be ignited in order to obtain the best result, and owing to the difficulty of maintaining each cylinder of an engine in identical conditions in these respects, it is obvious that an ignition system that does not take such variations into account cannot be perfect.

The Ackermann system of steering, invented nearly 100 years ago for horse-drawn vehicles, is now almost universally employed for all road motors, except traction engines. Each of the steering wheels turns separately on a vertical pivot, which should, theoretically, pass centrally through the vertical plane of the wheel and its contact with the ground. An obstacle met by the wheel would then have no tendency to disturb the steering of the car. The said arrangement is difficult to obtain mechanically, and a compromise is sometimes made by inclining the pivots or by inclining the wheels. It is not easy to see how the best types of the present system can be improved, although it must be admitted that none is perfect.

Horizontal cylinders may be lubricated by feeding oil through a hole in the cylinder on to the piston, allowing a portion to flow through a hole in the piston to lubricate the gudgeon pin. The oil is drained away at the front end of the cylinder, and is not used again. In vertical engines splash lubrication is generally employed for the lubrication of the piston, gudgeon pin, and in many cases the crank shaft and other engine bearings. The oil in this system is thrown up from the crank chamber by the crank dipping

into it. At the best it seems to be a happy-go-lucky method of a most unscientific order; the only thing which can be said in its favour is that in actual practice it has been found to work. For crank shafts and similar bearings a forced feed system would be better, provided some perfect system for road motors could be found of freeing entirely the oil from grit before refeeding it to the bearings. Bath lubrication of gear wheels is effective as regards lubrication, but absorbs power in churning up the oil.

There is still a good deal that can be effected in design in reducing friction by the substitution of ball or roller bearings for plain ones in suitable places, and by the use of metals having a low coefficient of friction. There are many ways in which power can be lost between the engine and the road wheels. None of the many forms of friction clutch can be depended upon not to slip in the way that a clutch which is positively engaged can. The use of Hooke's universal joints involves loss in transmission, as is demonstrated by the rapidity with which they often wear. The total transmission losses are not accurately known under road conditions, but it may be indirectly estimated that such losses may amount to from 20 per cent. to 40 per cent., or even more.

The advantages of pneumatic tires, owing to their resilience and low resistance, are counterbalanced by their high cost, rapid wear, and vulnerability. Methods of decreasing the vulnerability are only obtained at the sacrifice of other, and possibly more important, qualities. Owing to the large area of contact with the ground, and consequent low pressure per unit of contact area, the coefficient of friction is so small that skidding occurs if the road is greasy. No remedy has been found which does not impair the action of the tire as a pneumatic one. Again, owing to the rapidity of recovery of the tire on passing over an obstacle, oscillatory movement of the vehicle is started, and, given favourable conditions of speed and road, may be maintained, or even increased, to a dangerous extent. A partial remedy exists in the shock absorber applied between the sprung and unsprung portions of the vehicle. An inherent defect of the pneumatic tire is its dust-raising properties. The tire raises the dust, and the eddies produced by the passage of the car scatter it far and wide. This subject is one which is attracting the attention of the authorities representing road-makers and users. So far, the only effective remedy has consisted in treatment of the surface of the road.

The study of the composition of the exhaust gases is of importance. It ought to be possible to ensure that the exhaust gases contain not more than 1 per cent. of carbonic oxide. Governing by retarding the ignition is effective, but is objectionable on account of its liability to increase the percentage of CO in the exhaust; it is also unscientific, and very wasteful of fuel.

To obtain an average speed of twenty miles per hour, experience tells us that the maximum speed will not be less than 50 per cent. greater than the average during some periods of the journey; assuming a moderate efficiency of transmission of power, the provision of an engine capable of giving 1 brake-horsepower per hundredweight of the gross weight of the vehicle and its load of passengers, etc., would not be excessive.

Deductions made from data known to be approximately correct for the speed, power, and wind area of various cars having ordinary touring bodies lead to the formula $P = 0.0017AV^2$, in which P = resistance in pounds per square foot, A = projected area of car in square feet, and V = velocity in feet per second. Experiments are needed to provide data as regards the forms of car offering the least resistance to the air.

The gross ton-miles which should be obtained from a gallon of petrol of about 0.720 specific gravity at a speed of twenty miles per hour should not fall below thirty under ordinary conditions. There is room for improvement in this. Many other items, tires especially, have to be considered, which swell the bill to such an extent as to render the cost of fuel but a small part of the whole.

The weight of a pleasure motor-car is

high compared to the useful load of passengers. The useful weight in this case would be about one-quarter of the weight of the vehicle. Medium-weight passenger or goods' vehicles may carry a useful load of three-quarters the weight of the unladen vehicle; heavy vehicles having a slow speed may carry a load equal to the weight of the vehicle. It would appear that some improvement may be reasonably looked for in the reduction of the weight of the car as compared with its useful load.

Brakes on the steering wheels give immunity from skidding, but are very difficult to arrange for. It is best to apply both brakes required by law to the driving wheels, rather than to have one of them applied to the secondary transmission shaft. The distance in which a car can be pulled up without damage to the tires on an ordinary road and under normal conditions may be approximately found from the formula $S = 0.04V^2$, where V is in miles per hour and S is the distance in yards in which the car should come to rest. At ten miles per hour it should stop in 4 yards, and at twenty miles per hour in 16 yards. These distances are greater than is desirable, and also greater than most drivers would be prepared to admit, probably owing to time, and not distance, being the factor that a driver judges by when called upon to stop quickly. Improvement is only to be sought for in increasing the surfaces of adhesion, as by braking all four wheels, or by more equal distribution of the braking effect than we have at present.

Petroleum spirit is practically the only fuel employed; other fuels which might be used are petroleum, paraffin, benzol, and alcohol. Suction gas producers may be used for the heavier classes of vehicles.

PUBLICITY FOR RAILWAY ACCIDENTS.

A DISCUSSION OF THE POLICY OF PUBLICITY RECENTLY ADOPTED BY THE UNION PACIFIC RAILWAY.

W. L. Park—Western Railway Club.

THE traditional policy of secrecy and concealment, which has so long governed railway officials in dealing with accidents involving serious loss of life, has recently been abandoned by the Union Pacific Railway Company for a policy of admitting the public to full knowledge of the facts connected with accidents, as determined by official investigation. Each serious accident is now investigated by a board comprised mainly of officials of the road but with one or more members selected from outside sources, citizens of prominence in the locality in which the accident occurred usually being invited to act. Every facility is given the investigating board thoroughly and impartially to examine all available data bearing on the cause of the accident and their report, giving their conclusions as to the cause and, whenever possible, fixing the responsibility, is given the freest publicity. The causes which impelled the Union Pacific to make this radical change in policy are outlined in the following extracts from a paper read by Mr. W. L. Park, the General Superintendent, at the March meeting of the Western Railway Club.

"As railway men we must admit that the long list of appalling accidents, accompanied with fatalities and personal injuries to passengers and employees, many of which were avoidable, is a blot on our escutcheon which must be wiped out. How this may be accomplished is the one great problem confronting operating officials and employees. The solution unquestionably lies in the direction of taking the public into our confidence, making them feel that they have as great responsibility in upholding the law in the government of the ordinary affairs of life. Publicity for accidents, placing the same responsibility upon those who violate the rules of safety as is now placed upon those who in other

ways do the public a harm, will certainly bring about a very different conception of duty.

"Railway men of sufficient length of service cannot fail to compare the *esprit de corps* of a few years ago with conditions existing on American railways to-day. Instead of that intense interest and voluntary loyalty, we have a lethargic performance of duty, and a very pronounced indifference to the employer's interests, with almost studied effort to render such service only as may be contracted for, to the extent that on some railways there is actually in vogue a system of fines assessed against trainmen who do more than their schedules provide, and those who are known as 'company men' are unpopular among their fellows everywhere. The loss of this voluntary loyalty is most severely felt in the discipline. The pecuniary losses (through indifference inviting adverse public sentiment) are great and to be deplored, but the loss of reputation and confidence in railroad management is one that falls heavily on every official and employee connected with a railroad, making them vulnerable to the attacks of enemies, who are ever watchful of such opportunities.

"While we do not contend that the employees' organizations sanction or even encourage indifference, force of circumstance undoubtedly carries the members under their protection into such a line of thought and action that the service is unconsciously tainted thereby. Such influence of organizations is not by any means confined to the members. It affects other employees, and even the officials, who are expected to administer discipline impartially, influencing their decisions through fear of being reversed by superiors, who may be actuated by motives foreign to the case under consideration.

"The responsibility is not, by any means, entirely with the rank and file. Employees in self-defense have been forced into co-operation for mutual protection against petty persecutions and discriminations on the part of the railway officials. The organizations are expensive to maintain and, at times, exact from the members sacrifices not in accord with the spirit of independence bequeathed them in the Declaration of Independence. The yoke is galling, but must be worn until such time as officials are so surrounded with established methods of discipline as will do away with the injustice and vindictiveness in fixing penalties. Our present system is primitive and barbarous, it insults the intelligence of employees and forces them into alliances for self-protection. Once having the power, they naturally exercise it in directions not originally intended.

"While I may be telling a family secret, it is a fact that not a few railway accidents are white-washed in the investigation to the extent that the officials even deceive themselves. The evidence is often made to substantiate a preconceived conclusion as to how the accident occurred. The dominant influence of one in authority frequently asserts itself to the extent that the interrogating or giving of testimony is shaped to meet the well known views of a superior. This influence may be unconsciously exerted or absorbed.

"If our English cousins, through the Board of Trade can investigate accidents with unquestionable diminution as a result, and the German and other powers of continental Europe through ministers of railway affairs, can bring the heavy hand of the government to bear upon the transgressor of good practice (whether he be employee or official) to the end that few avoidable accidents occur, it is not looking far ahead to find our duties circumscribed by conditions much more perplexing than now exist. It is not certain by any means that we shall stop with that which satisfies the conservative Englishman or phlegmatic German. We are not yet old enough to assume such responsibilities.

"Unless railway men are willing to let the politicians take from their hands the reins and govern the roads with inexperience and theory, they must analyze the present conditions and shape the future policy in this respect in accord with the growing sentiment that accidents are of too frequent occurrence and,

unless prevented to a greater degree than now obtains, the strong arm of the government must interfere, be the consequences what they may. Unless railway managers merit such confidence by an impartial and thorough investigation of such accidents as disturb the public welfare, such power will be taken from them. A competent railway operating official ought not to fear publicity for accidents. He should be so well grounded in his methods as to invite publicity. The public will help him to place the responsibility where it belongs, and secure for him the individual responsibility, which is essential to any well managed property. As it now stands, the managers must bear wholly the odium of a disregard of the rules. If an accident occurs the men implicated will frequently accuse the officials of not enforcing the rule, a violation of which was responsible, alleging that custom superseded it.

"The Union Pacific is perhaps the first railway adopting this method. We approached it with no little timidity. Our legal department said it would throw open information upon which claims would be made for damages and personal injuries. As a matter of fact nothing of this kind has occurred. On the contrary, the accident having been thrown open to full public investigation, there are no mysteries for the opposition to delve into; no vague insinuation that the great corporation is crushing the helpless client by suppressing the facts (which is always a stock in trade with the plaintiff in a damage case). That such investigation helps the legal department there is no doubt."

THE PRECIPITATION OF COPPER FROM MINE WATERS.

A DESCRIPTION OF BUTTE PRACTICE IN THE RECOVERY OF COPPER FROM MINE WATERS AND OLD TAILINGS PILES.

Charles J. Stone—Engineering and Mining Journal.

THE precipitation of copper from mine waters in the Butte district, which was begun on an experimental scale a little over ten years ago, has been developed into an industry of large and increasing commercial importance. No less than 30 precipitating and leaching plants are now operated by the large mining companies, the leasers, and individuals who take the tail waters from the larger operators. The output of cement, or precipitated, copper is about 750 tons per month, averaging about 60 per cent pure copper. An interesting description of the practice by which it is recovered, and also of the method of leaching tailing piles, is given by Charles J. Stone in the *Engineering and Mining Journal* for May 8.

"Great difficulty was at first experienced by the mining companies to find something that would withstand the action of the mine waters on pumps and pipes and that would be within a reasonable cost. Phosphor-bronze castings were found to be necessary for the entire water end of all pumps where the water was found to be even slightly acid. The phosphor-bronze is composed of 93 per cent. copper, 0.5 per cent. phosphorus, 4.5 per cent. tin and 2 per cent. lead. This metal, however, was much too expensive for pipes, and a cheaper material had to be found.

"Flanged-steel pipes with lead gaskets and lead linings were found to withstand the action of the water with a degree of satisfaction, but wood-lined pipe, which is less expensive, is now in practically universal use throughout the Butte district. For high-pressure water columns in shafts and other lower pressure pipes, a flanged-steel pipe is used and the wooden lining forms a male and female connection at the joints. The lining is composed of pine slats put in place with hot asphaltum and the key piece is fitted and driven in firmly, so that the lining is held tightly in place. The whole pipe lining is then carefully painted with asphaltum, and when the pipe is put in place, great caution is

taken in packing the joint to prevent seepage. In shafts where water from the upper levels drips on the pipes, it has been found necessary thoroughly to paint and cover the pipes with canvas, and the canvas then receives a thick coat of asphaltum. Wooden, wire-bound pipes are also used underground for light service, and on the surface wooden launders or flumes are used and give satisfactory service.

"The copper content, as well as all other mineral salts and the amount of free acid contained in the mine waters, varies widely in different mines and different sections in the district. Cupriferous waters were not encountered to any great extent in the upper levels, nor at shallow depths, but when the shafts penetrated the great copper horizon at from 500 to 2,200 feet in depth, the waters were found to be highly charged with mineral salts and free acid. Old workings, abandoned upper levels and gob or stope fillings that have long been exposed to the oxidizing influence of air and where waters leach through them, are productive of the highest grade of cupriferous water. When a deep level is opened, the flow is found to contain free acid, but only a small amount of copper sulphate is present. As the levels become opened and decomposition of the sulphides takes place, the water is enriched sufficiently to make the recovery of the copper profitable.

"A flow coming from a section where the sulphide ore is burning or from a level where the fire has been extinguished, is enriched remarkably. The mine water of the Boston and Montana has been built up within a short period from this source alone from 0.02 per cent. copper content to above 0.2 per cent., and at this strength it threatened to destroy the phosphor-bronze castings of the pumps. For this reason an effort is made, where possible, to regulate the grade of water to a strength that will not have a corrosive effect on the bronze pump parts.

"The cupriferous water from the various mines carries from 0.01 per cent. to 0.031 per cent. copper as copper sulphate. The process to recover this by passing the solution over scrap iron is simple. The iron supplants the copper in its union with the sulphate radical, the copper being precipitated as a crystalline powder, while the sulphate of iron is carried off in solution. It would appear that the mine waters are extremely poor in copper as compared with the solutions in a leaching operation, but when a mining company is pumping 500 gallons a minute, the precipitation amounts to approximately 1,600 pounds of copper per day and the saving is effected with but little expense either in first cost or cost of operation.

"The copper precipitation is effected in open launders and in towers. The launders are set at sufficient grade so that the water flows rapidly, and scrap iron of all classes is thrown into it, but care is taken to allow the water to flow freely. The launders are from 3 to 4 feet wide and from 1 to 2 feet in depth, and are built single or double. The water is kept at from 6 to 12 inches in depth in the launders. If the water as it comes from the mine is strong in acid, better results are obtained where the water flows at a greater velocity, but if weak in acid, a slower flow is desirable. It is well at all times to keep the iron and launders free from accumulations of iron oxide. Frequent cleaning is necessary for this purpose.

"The towers are built from 8 to 12 feet wide, 10 to 14 feet high, and from 50 to 150 feet long, the size depending entirely upon the flow to be handled. They are built open on sides and ends, and large scrap sheets of iron are placed to hold the dripping water within the water-tight bottom; or they are inclosed entirely on all sides by baffle boards to keep all water within the tower sump. The water comes into the top of the tower in an open launder and the flow is regulated by means of gates and side distributing troughs so that the shower is uniform throughout the tower. The tower is filled with scrap iron for perhaps one-quarter to one-half its height. Experience has shown that a better extraction is effected in the towers than in the launders. This is especially noticeable where the solution is both

weak in acid and copper. Doubtless exposure to air has a beneficial effect, but the arrangement is more efficient in that the falling water keeps the scrap clean and bright, and prevents an accumulation or iron-oxide slimes, one of the difficulties of launder practice.

"A clean-up is effected by turning the flow into other launders of the plant, scrubbing and washing the scrap free from copper scale and sluicing the launders and tower sump into settling vats, where the clear solution is decanted off. The cement copper is then dried, barreled and shipped to Great Falls where it is smelted in reverberatory furnaces. The average quality of the precipitate is between 60 and 70 per cent. copper.

"A well-arranged plant is so located that the solutions can flow by gravity from the mine through the launders and down through towers, with the clean-up vats below. It is well to place the clean-up vats and dryer under the same roof. The extent or magnitude of the plant depends upon the limit of extraction it is found profitable to make from the solution. All launders and towers should be built in parallel duplicates so as to facilitate rapid and thorough cleaning. Wrought and steel scrap are better than cast iron and thin sheets are more satisfactory than heavy pieces. On an average, about 75 pounds of cement or precipitated copper are recovered in practice from the consumption of 100 pounds of scrap material.

"A number of the large tailings dumps from the early concentrating mills, which were neglected for years, are being worked successfully in connection with the precipitation of copper from mine waters. The dumps carry approximately 1 per cent. of copper. Years of weathering have made possible the leaching of these tailings on a profitable basis. The dumps are from 20 to 50 feet in depth and cover many acres of ground. The James Gillie lease, operating on the old sands of the Montana Ore Purchasing Company, is worth studying from an engineering and economic standpoint. The dump, which is located in the bed of Silver Bow creek, contains upward of 200,000 tons of sands. They are of considerable extent and average from 20 to 30 feet in depth.

"The supposedly barren tail water from the precipitating towers of the Boston and Montana Company is elevated to the highest point on the dump. Ponds of from 5,000 to 15,000 square feet are arranged so that the overflow from the higher will run to the next lower pond until the entire flow is absorbed. To reclaim the water after it has leached through the sands and taken up the soluble copper, two level tunnels were driven through the dump on the slime-covered soil of the valley. A cribbed trench surrounds the dump. The tunnels and trench lead to a common sump whence the water carrying the copper solutions is elevated into the precipitating towers or flows by gravity into the precipitating boxes.

"The water which is fed to the ponds contains but a trace of copper and is very weak in free acid. After leaching, its copper content has been built up to 0.02 per cent. and precipitation is satisfactory. The product from this particular plant averages 80 per cent. copper. They are pumping 750 gallons of mine water per minute upon the sands and, approximately, 80 per cent. of this is recovered and fed to the precipitating plant. A daily analysis of the leached solution will give a close estimate of the daily recovery of copper.

"This method of leaching, while attended with serious losses in solutions is possibly the only method by which the sands can be treated commercially. However, it does not prove that it would not be advisable to convey the sands to leaching tanks and add a small amount of sulphuric acid to assist extraction. A 20 per cent. loss in solution on the method that now obtains at this plant amounts to a loss of 324 pounds of copper per day. This, doubtless, sinks into the soil of the valley and is beyond recovery. As far as known to be writer, no regrinding and leaching test has ever been made on Butte tailings to determine if they can be worked commercially on a large scale."

THE ENGINEERING INDEX

"THE KEYSTONE IN THE ARCH OF APPLIED SCIENCE"

The following pages form a descriptive index to the important articles of permanent value published currently in about two-hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every publication:

(1) The title of each article,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published,
(7) *We supply the articles themselves, if desired.*

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer, superintendent or works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of every article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the principal journals indexed are given.

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CIVIL ENGINEERING.

BRIDGES.

Bascule.

The New Knippels Bridge at Copenhagen. Illustrations and particulars of a new bridge of the bascule type showing the ornamental possibilities. 1200 w. Sci Am—May 29, 1909. No. 5023.

Concrete.

Concrete in Highway Bridge Abutments. A. W. Campbell. Presents its advantages and discusses the design, dimensions and permanence. 2500 w. Con Rec—May 12, 1909. No. 4676.

Culverts.

Relative Economy in Cost of Culvert Construction. E. W. Cooper. Gives cost estimates based on the cost to the railroad company having the work done. 1500 w. Can Engr—April 30, 1909. No. 4378.

Failures.

The Collapse of a Reinforced-Concrete Bridge Across the Illinois River at Peoria, Ill. Information concerning this bridge and the accident, received from various sources. Ills. 6000 w. Eng News—May 13, 1909. No. 4649.

Reconstruction.

Reinforcing a Highway and Street Railway Bridge. Describes methods used for strengthening the steel work of the Washington bridge over the Housatonic

We supply copies of these articles. See page 723.

River in Connecticut. 1800 w. Eng Rec—May 15, 1909. No. 4697.

Reinforced Concrete.

Transverse Beams in Girder Bridges (Querträger bei Balkenbrücken). K. Oswald. Mathematical discussion of their design. Ills. 2500 w. Beton u Eisen—April 23, 1909. No. 5052 F.

The Construction of the Grand River Bridge. Illustrated description of unusual construction methods used for this four-track reinforced-concrete arch bridge of the L. S. & M. S. Ry. near Painesville, Ohio. Also editorial. 4500 w. Eng Rec—May 1, 1909. No. 4389.

See also Failures, Trestles, and Viaducts, under BRIDGES.

Replacement.

Replacing a Double-Track Skew Bridge and Viaduct. Plans and description of methods of replacing the entire superstructure without obstructing the tracks below or interrupting train service. 2000 w. Eng Rec—May 8, 1909. No. 4577.

Skew.

See Replacement, under BRIDGES.

Steel.

Bridge Designing. Carl Gayler. Remarks on work of the past forty years, drawing lessons from the Quebec bridge failure and discussing the Eads bridge in comparison. 3500 w. Jour Assn of Engng Socs—March, 1909. No. 4908 C.

Tables for Calculating Inertia of Built-Up Girders. H. F. Harris. Gives useful tables for shortening time necessary for calculations. 1000 w. Mech Engr—April 23, 1909. No. 4455 A.

Proportioning Bridge Members for Impact. Editorial reviewing briefly methods of proportioning bridge members, and considering certain impact formulae. 2500 w. Eng Rec—May 8, 1909. No. 4570.

The 42 St. Bridge, Philadelphia, Pa.; An Arch with Steel Ribs Filled Between with Concrete. Plans and description of a combination steel and concrete highway bridge having novel features. 3000 w. Eng News—May 20, 1909. No. 4777.

A Combination Steel and Concrete Arch Bridge. Illustrated description of a bridge being erected in Philadelphia, to carry 42d street over 15 tracks of the Pennsylvania R. R. 2000 w. Eng Rec—May 22, 1909. No. 4923.

The Doumer 1,680-Metre Bridge Over the River Rouge at Hanoi, Tonkin (Le Pont Doumer de 1,680 Mètres d'Ouverture sur le Fleuve Rouge à Hanoi, Tonkin). Illustrated detailed description. 4000 w. Génie Civil—April 3, 1909. No. 4834 D.

See also Replacement, under BRIDGES.

Suspension.

The Stresses in a Suspension Bridge. L. H. Chase. Gives a simple method of calculating the stresses by simple mathematics. 3000 w. Engr, Lond—May 7, 1909. Serial. 1st part. No. 4728 A.

Trestles.

Reinforced-Concrete Trestles with Pile Bents and Girder-Slab Spans: Chicago, Burlington & Quincy Ry. Illustrated description of the construction. 2500 w. Eng News—May 20, 1909. No. 4779.

Viaducts.

The Stability of Viaduct (Remarques sur la Stabilité des Viaducs). M. Bonneau. Mathematical discussion. 8000 w. Ann d Ponts et Chaussées—1909-I. No. 4813 E + F.

Early Construction Methods on the Grand Avenue Viaduct. The erection of this viaduct in Milwaukee, Wis., is illustrated and described. 2500 w. Eng Rec—May 22, 1909. No. 4925.

The Sligo Reinforced Concrete Viaduct. Brief illustrated description of a highway viaduct in Takoma Park, Md. 1500 w. Eng Rec—May 15, 1909. No. 4687.

CONSTRUCTION.

Brick.

The Auditorium-Armory Building in Atlanta, Georgia. Plans and description of a brick building on concrete footings, on firm clay. The interior construction consists of a combination of frame, steel and concrete. 2000 w. Eng Rec—May 8, 1909. No. 4576.

Building Costs.

Comparative Cost of Reinforced-Concrete, Stone, Brick and Frame Buildings. Oliver Randolph Parry. Gives contractors' estimates, with comments. 900 w. Cement Age—May, 1909. No. 4754 C.

Coal Pockets.

See Coaling Plants, under RAILWAY ENGINEERING, PERMANENT WAY AND BUILDINGS.

Columns.

Compressive Strength of Concrete-Filled Iron Columns (Zur Beurteilung der Knickfestigkeit betongefüllter Eisensäulen). Joh. E. Brik. Mathematical discussion of its computation. Ills. 3500 w. Oest Wochenschr f d Oeffent Baudienst—April 3, 1909. No. 4893 D.

Concrete.

A Concrete House. Illustrated description of a house at Doylestown, Pa. 2000 w. Cement Age—May, 1909. Serial. 1st part. No. 4753 C.

The Design and Construction of a Concrete House. John Wynkoop. The first of a series of articles giving sketch plans, elevations, perspective and working drawings and details for the design and construction. 2000 w. Cement Age—May, 1909. Serial. 1st part. No. 4752 C.

See also Wharves, under WATERWAYS AND HARBORS.

Cost Keeping.

A System of Cost Keeping. Discussion of Myron S. Falk's paper. 3000 w. Pro Am Soc of Civ Engrs—May, 1909. No. 5110 E.

Earthquake.

Earthquake Construction (Erdbebensichere Bauten). F. von Emperger. Discusses the principles of safe construction of various parts of buildings. Ills. Serial. 1st part. 3300 w. Beton u Eisen—April 23, 1909. No. 5051 F.

Construction for Regions Subject to Earthquake Shocks (Norme edilizie per e Paesi sogetti a Terremoti). A. Pacchioni, G. C. Baravelli and others. An exhaustive discussion of the subject. 37500 w. Ann d Soc d Ing e d Arch Ital—April 1 and 15, 1909. No. 4844, each F.

Fireproof.

See Fireproofing, under MATERIALS OF CONSTRUCTION.

Foundations.

Foundations of the Northwestern Railway Terminal, Chicago. Describes work on caisson foundations under unfavorable soil conditions. 3000 w. Eng. Rec—May 8, 1909. No. 4572.

The Reinforced Concrete Foundation of the New York and Richmond Gas Company's New Gasholder at Clifton, Staten Island. R. P. Raynesford. Illustrated description. 900 w. Am Gas Lgt Jour—May 3, 1909. No. 4387.

Framed Structures.

The Theory of Rigid Frames (Beitrag zur Theorie des steifen Rahmens). Emil Morgenstern. Mathematical. Ills. 3000 w. Beton u Eisen—April 2, 1909. No. 4898 F.

Gas Holders.

See Foundations, under CONSTRUCTION.

Piling.

The Development and Use of Steel Sheet Piling, with Some Data on the Preservation of Steel Buried in the Ground. J. R. Wimlinger. Read before the Technical League, N. Y. City. 4000 w. Engng-Con—May 19, 1909. No. 4797.

Concrete Piles. Howard J. Cole. Presents the advantages of the various types, describing the methods of driving and giving data of bearing power, cost, etc. Ills. 8500 w. Pro Am Soc of Civ Engrs—May 1, 1909. No. 5105 E.

Built-Up Concrete Slab Piles and Pile Protection. Illustrates and describes a form of pile used in England, which allows renewals to be made without interfering with the use of the structure. 2000 w. Eng Rec—May 8, 1909. No. 4573.

A Reinforced-Concrete Pile Foundation (Eine ausgeführte Gründung mit Beton-Blechrohr-Pfählen). Richard Kafka. Illustrated description of work with piles reinforced on a new system. 3000 w. Zeitschr d Oest Ing u Arch Ver—April 9, 1909. No. 4892 D.

Reclamation.

Reclamation and Development of the New Jersey Coast. George L. Watson. Describes this work at Five Mile Beach, especially methods of sewer and street construction. Ills. 2500 w. Can Soc of Civ Engrs—April 15, 1909. No. 4532 N.

Reinforced Concrete.

The Artistic Treatment of Reinforced Concrete (Die künstlerische Lösung des Eisenbetonbaues). István Medgyaszay. A discussion of the artistic possibilities of the material, illustrated with examples of recent structures. Serial. 1st part. Beton u Eisen—April 23, 1909. No. 4899 F.

Reinforced Concrete Dome of the Porto Rico Capitol. Illustrated detailed description of this feature of the new capitol. 1500 w. Eng Rec—May 1, 1909. No. 4393.

Construction and Reconstruction. J. P. H. Perry. Illustrates and describes the model factories of the Bush Terminal Co., built of reinforced concrete on unimproved land; and also the reconstruction of the King plaster mill in the same material, while in operation. 2200 w. Ins Engng—May, 1909. No. 4990 C.

Reinforced Concrete Construction in the Basel Municipal Theatre (Die Eisenbetonkonstruktionen des Stadttheatres in Basel). Illustrations with brief description of the construction. Serial, 2 parts. 2000 w. Schweiz Bau—April 3 and 10, 1909. No. 4875, each B.

The New Theatre in Copenhagen (Das neue Theater in Kopenhagen). E. Suenson. Illustrated description of interesting construction in reinforced concrete. 3300 w. Beton u Eisen—April 23, 1909. No. 5050 F.

The Printing House of Oskar Brandstetter in Leipzig (Noten- und Buchdruckerei Oskar Brandstetter in Leipzig). Em. Haimovici. Illustrated description of interesting features. 2500 w. Beton u Eisen—April 2, 1909. No. 4896 F.

See also Foundations and Roofs, under CONSTRUCTION; Sewers, under MUNICIPAL; Pipes, Water Towers and Weirs, under WATER SUPPLY; and Coaling Plants under RAILWAY ENGINEERING, PERMANENT WAY AND BUILDINGS.

Roofs.

Kahn Reinforced Concrete Roof Over Extension to National Gallery. Illustrated description of interesting work in progress in London. 600 w. Engng—April 23, 1909. No. 4461 A.

Steel.

Essential Formulae in Structural Engineering. Horace Cubitt. Read before the Inst. of Munic. Engrs. Aims to show that the real essential formulae for structural engineering purposes are few. 3000 w. Archt, Lond—April 30, 1909. Serial, 1st part. No. 4594 A.

Erecting the Allegheny County Soldier's Memorial. Illustrated description of the erection of a steel-frame building in Pittsburg, Pa. 1000 w. Eng Rec—May 15, 1909. No. 4690.

We supply copies of these articles. See page 723.

Timber Splicing.

A Neglected Splice for Timber Tension Members. Robert Fletcher. Discusses forms of splicing used, and their applications. 1500 w. Eng News—May 20, 1909. No. 4776.

Tunnels.

The Sigafoos Tunnel Machine. Rowland Ashford Phillips. Illustrated detailed description of a rotary tunneling machine recently given trial with great success. 1600 w. Sci Am—May 22, 1909. No. 4903.

The Crossing of Sidney Harbor, New South Wales. An account of the final solution of conveying passengers across a deep and wide tidal channel, by constructing a tunnel similar to the system employed at the Detroit River. 2000 w. Engr, Lond—May 14, 1909. No. 4968 A.

Rapid Progress in a Hard-Rock Tunnel. A report of the rate of speed attained on the Roosevelt drainage tunnel at Cripple Creek, Colo. 1500 w. Eng Rec—May 1, 1909. No. 4390.

Wrecking.

Wrecking the Old City Hall in Chicago. Brief description of the removal of massive buildings. Ills. 1500 w. Eng Rec—May 15, 1909. No. 4693.

MATERIALS OF CONSTRUCTION.

Brick.

Silico-Calcareous Bricks. E. Leduc. From a paper in the *Bul de la Soc. l'Encour, pour l'Ind. Nat.* Deals with the history, economic development, manufacture, etc. 3000 w. Quarry—May, 1909. Serial, 1st part. No. 4660 A.

Cement Testing.

The Micrographic Study of Portland Cement (Lo Studio micrografico del Cemento Portland). A discussion of its usefulness, with illustrations. 2500 w. Il Cemento—April 30, 1909. No. 4849 D.

Concrete.

The Dangers of Breeze Concrete. Discusses the experiments recently carried out by D. B. Butler. Ills. 1000 w. Engng—April 30, 1909. No. 4625 A.

Good Concrete and How to Get It. Frank M. Okey. From a paper before the Iowa Cement Users Assn. Discusses the effect of the different materials used. 2000 w. Munic Engng—May, 1909. No. 4549 C.

Fireproofing.

Fireproofing Solutions (Feuersichere Imprägnierungsmittel). Herr Wendt. Describes various materials used for impregnating wood, etc., for fireproofing purposes. 2500 w. Gesundheits-Ing—April 24, 1909. No. 4890 D.

Lime.

The Testing of Lime for Building Uses. A. G. Larsson. Proposes simple methods of testing. 2000 w. Con Rec—May 12, 1909. No. 4677.

Paints.

Physical Tests of Protective Coatings for Iron and Steel. J. Cruickshank Smith. Read before the Iron and Steel Inst. On the value of such tests in the selection of protective coatings. 2500 w. Engng—May 14, 1909. No. 4961 A.

Reinforced Concrete.

Results of Tests of Deflection of Reinforced Concrete T-Beams. A. B. White. A portion of a graduation thesis on tests made at Swarthmore College. 1200 w. Engng-Con—May 12, 1909. No. 4655.

Tests of Reinforced Concrete Beams. Resistance to Web Stresses. Series of 1907 and 1908. Arthur N. Talbot. An account of investigations made and information gained. 20000 w. Univ of Ill, Bul 29—Jan. 4, 1909. No. 4755 N.

The Effect of Repeated Stress on the Bond between Concrete and Clean and Rusted Iron (Einfluss wiederholter Beanspruchung auf die Haftfestigkeit von Beton an Eisen mit reiner und verrosteter Oberfläche). Bernh. Kirsch. Results of tests. 2400 w. Oest Wochenschr f d Oeffent Baudienst—April 24, 1909. No. 4894 D.

MEASUREMENT.

Hydrographic Surveying.

See Survey Vessels, under MARINE AND NAVAL ENGINEERING.

Leveling.

Precise Leveling of the Coast and Geodetic Survey. Henry W. Maynard. Describes the methods used in work by the United States Government. 4000 w. Cornell Civ Engr—May, 1909. No. 4742 C.

Stream Gauging.

Stream Gaging in the West. W. B. Freeman. Gives some of the results obtained by the Hydrographic branch of the U. S. Geological Survey, describing features. Ills. 2500 w. Cornell Civ Engr—May, 1909. No. 4743 C.

The Design of Cable Stations for River Measurements. J. C. Stevens. Illustrated detailed description of the design of river-gaging stations where cables are required. 1800 w. Eng News—May 6, 1909. No. 4519.

MUNICIPAL.

Drainage.

The Design of Drainage Canals and Pipe Lines (Zahlenbeispiele zum Berechnen von Rohrleitungen und Kanälen für Entwasserungsanlagen). Adolf Städing. Mathematical solution of several common problems. Ills. Serial, 1st part. 6500 w. Gesundheits-Ing—April 17, 1909. No. 4888 D.

Experiences in Working Separate Drainage Canals (Ueber Erfahrungen im Betriebe getrennter Entwasserungskanäle). H. Metzger. Compares the operation of separate storm-water and sewer-

age systems with the combined system. 3000 w. Gesundheits-Ing—April 17, 1909. No. 4887 D.

Pavements.

Some Experiments on the Resistance of Pavements. A. C. D. Blanchard. An account of experiments in Toronto to show the influence of heavy grades on the resistance to tractive effort, giving results. Ills. 1000 w. Can Soc of Civ Engrs—April 29, 1909. No. 4552 N.

Causes and Prevention of Defects in Asphalt Pavements. Isaac Van Trump. From an address at Notre Dame Univ., Ind. Discusses the main causes, showing that many are under the control of the municipal engineer. 1200 w. Munic Engng—May, 1909. No. 4551 C.

Public Baths.

Public Baths. Jno. K. Allen. Illustrated detailed descriptions of modern public baths in America, with information relating to them. 5500 w. Dom Engng—May 22, 1909. No. 4975.

Public Baths in School House Basements. Reuben S. Bemis. Brief illustrated outline for bath-house plan. 800 w. Dom Engng—May 22, 1909. No. 4976.

Refuse Disposal.

Electricity Works and Refuse Destructors. J. A. Robertson. Abstract of paper before the Glasgow Sec. of the Inst. of Elec. Engrs. Deals with the nature of the problem, the most important points in destructor design, and gives results at Greenock. 5500 w. Elect'n, Lond—April 23, 1909. No. 4450 A.

The Economy of Refuse Destructors (Over vuilnisverbrandingsovens en daarmede te verkrijgen uitkomsten). J. C. H. Fischer. Gives results in England and on the Continent. Ills. 8000 w. De Ingenieur—April 17, 1909. No. 5081 D.

Garbage Incineration and Garbage Destructors (Note sur l'Incinération et sur les "Destructeurs" d'Ordures ménagères). E. Damour. Discusses the qualities required in an incinerator. 2500 w. Bul Soc d'Encour—April, 1909. No. 4867 G.

Roads.

Width of Roads and Provision of Footpaths. William Harpur. Read at Road Conference, London. Indicates the writer's views and the changes needed because of changed conditions. 2500 w. Surveyor—May 7, 1909. No. 4711 A.

Road Grades (Sulla Pendenza delle Strade ordinarie). Giulio Stabilini. A mathematical discussion of highway grades and traction. Ills. Serial, 1st part. 2500 w. Monit Tech—April 30, 1909. No. 4847 D.

Road Construction, Curves, Gradients and Camber. H. T. Wakelam. Also papers by Col. R. E. Crompton, Lord Leigh, Rev. Canon Rawnsley, and Walter J. Fletcher, with discussion. Ills. 18600 w. Surveyor—May 14, 1909. No. 4950 A.

A Practical Road Talk. Albert S. Brainard. A discussion of road construction and preservation. Ills. 3000 w. Cornell Civ Engr—May, 1909. No. 4744 C.

Construction and Maintenance of Roads. George A. Phillips. Read at Road Conference, London. An account of methods in the county of Glamorgan, Wales. 2000 w. Surveyor—May 7, 1909. No. 4710 A.

Construction and Maintenance of Roads, Wear and Tear, Etc. Albert D. Greatorex. Read at Road Conference, London. Calls attention to causes of excessive wear and tear. 2500 w. Surveyor—May 7, 1909. No. 4709 A.

Construction and Maintenance of Roads, Wear and Tear, Etc. William Nisbet Blair. Read at Road Conference, London. Brief consideration of materials, construction, etc. 2500 w. Surveyor—May 7, 1909. No. 4706 A.

Road Maintenance. F. G. Carpenter. Read before the Road Conference, London. Discusses present conditions and difficulties and some methods of maintenance and construction. 2000 w. Surveyor—May 7, 1909. No. 4708 A.

Notes on the Tonnage-Life and Wear of Stones in Road Surfaces. John A. Brodie. Read at Road Conference, London. Calls attention to differences in wear of the same stone when used in varying forms of construction. 2000 w. Surveyor—May 7, 1909. No. 4707 A.

Wear and Tear of Motor Traffic on Roads. W. J. Taylor. Read at Road Conference, London. Discusses the injuries, their causes, and remedies. 1700 w. Surveyor—May 7, 1909. No. 4712 A.

Experimental Road Work by the Massachusetts Highway Commission in 1908. Reviews work with dust layers, road preservatives, new binders, resurfacing, etc. 7000 w. Engng-Con—May 5, 1909. No. 4533.

Homogeneous "Double-Sealed" Road 1500 w. Surveyor—April 23, 1909. No. 4453 A.

Sampittic Surfacing. Discussion of Walter William Crosby's paper. Ills. 6000 w. Pro Am Soc of Civ Engrs—May 1909. No. 5108 E.

Tar for Roads. C. P. Price. Read before the New England Assn of Gas Engrs. Explains the latest and best methods of using tar as a road preservative and in the construction of new roads. Ills. Discussion. 4000 w. Am Gas Lgt Jour—May 24, 1909. No. 4933.

Sewage Disposal.

Fundamental Principles of Sewage Purification on Land. Rudolph Hering. Reviews the phases of sewage purification, as based on a study of practice in Europe and America, especially consider-

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ing the physical conditions. 6500 w. Eng News—May 6, 1909. No. 4521.

Principles of Sewage Purification. George W. Fuller. A lecture at Cornell Univ. Remarks on conditions, outlining a series of problems and their solution as illustrated by actual projects. 4500 w. Eng Rec—May 15, 1909. Serial, 1st part. No. 4688.

Sewage Disposal and Purification. C. M. Arnold. A review of what has been accomplished and the methods proved successful. 2500 w. Can Engr—May 21, 1909. No. 4916.

The Purification of Sewage by Bacterial Treatment on Peat Beds (Etudes sur l'Epuration des Eaux d'Egout sur des Lits bactériens de Tourbe). A. Müntz and E. Lainé. A general review of the process and a discussion of its efficiency, with results of tests. Ills. 10500 w. Bul Soc d'Encour—April, 1909. No. 4868 G.

The Louisville Sewerage Improvements. Roger DeL. French. Map and illustrated description of extensive improvements, including an outfall sewer. 3000 w. Eng Rec—May 1, 1909. No. 4391.

Sewage Disposal at Columbus, Ohio. E. A. Kemmler. Illustrated detailed description of the sewage purification works consisting of septic tanks, sprinkling filters and settling basins, all constructed of concrete and steel, with data of operation. 4000 w. Munic Jour & Engr—May 5, 1909. No. 4514.

Sewerage of East St. Louis. Drawings and description of the pumping station and its equipment, and the concrete sewers. 2000 w. Munic Jour & Engr—May 5, 1909. No. 4515.

Sewerage Treatment at Bloomington, Ind. George L. Thon. Illustrates and describes the sewerage system for a town of about 8000 inhabitants. 2000 w. Munic Jour & Engr—May 5, 1909. No. 4516.

Ilford Sewage Disposal Works. Herbert Shaw. Read before the Assn. of Mgrs. of Sewage Disposal Works. Plan and description of method of treating domestic sewage. 2500 w. Surveyor—April 30, 1909. No. 4607 A.

See also Purification, under WATER SUPPLY.

Sewerage Statistics.

Sewerage Statistics. Collected and tabulated by the Sanitary Section of the Boston Society of Civil Engineers. 2500 w. Jour Assn of Engng Socs—March, 1909. No. 4912 C.

Sewers.

Methods of Sewer Construction in Clinton, Iowa. Charles P. Chase. From a paper before the Iowa Soc. Describes construction methods, giving instructions issued for work in freezing weather, and approximate costs. 2500 w. Munic Engng—May, 1909. No. 4550 C.

The Sewerage Work at Louisville, Kentucky. Roger DeL. French. Illustrates and describes the new outfall and intercepting sewers. 1000 w. Jour Worcester Poly Inst—May, 1909. No. 4991 C.

The Sewers of Belgrade and the Construction of the Upper Collecting Sewer (Einige Mitteilungen über die Kanalisation von Belgrad und den Bau des Hauptsammlers der oberen zone). Ludwig Roth. Illustrated description of extensive concrete sewer construction. 2000 w. Beton u Eisen—April 2, 1909. No. 4897 F.

See also Drainage, under MUNICIPAL.

WATER SUPPLY.

Dams.

The Griffin Concrete Dam. Illustrated description of a dam at Griffin, Pa., for supplying water for locomotive tanks on the B. & O. R. R. 1000 w. Eng Rec—May 15, 1909. No. 4691.

The Construction of a Spillway on the Tombigbee River. Detailed description of the methods of construction. Ills. 2000 w. Eng Rec—May 22, 1909. No. 4927.

Filtration.

Recent Upward Water Filters. Brief report of the arrangement of filter tanks at Jerome Park reservoir, New York. 700 w. Eng. Rec—May 15, 1909. No. 4695.

Alternative Designs for Hand-Washed and Machine-Washed Slow-Sand Water Filters, Borough of Queens, New York City. Illustrations and information supplied by I. M. de Varona, in regard to designs for a filtration plant at Bayside Pumping Station. 1800 w. Eng News—May 20, 1909. No. 4781.

The New Unsubmerged Sand Filters of Miquel and Mouchet (Les nouveaux Filtres à Sable non submergé Système de MM. le Docteur P. Miquel et Mouchet). Félix Marboutin. Discusses the efficiency of trickling filters, gives results of tests, and describes the Miquel and Mouchet system. Ills. 19000 w. Mem Soc Ing Civ de France—Feb., 1909. No. 4809 G.

Flumes.

Flow of Water in Flumes or Launders. R. E. Neale. Notes applying not only to natural water-courses, but to artificial flumes. 900 w. Prac Engr—April 30, 1909. No. 4606 A.

Ground Waters.

The Influence of Underground Air Currents on the Variation of Ground Waters (Der Einfluss der unterirdischen Luftstromungen auf die Mengenschwankungen des Grundwassers). Chr. Mezger. Serial. 1st part. 4500 w. Gesundheits-Ing—April 10, 1909. No. 4885 D.

Hydrostatics.

A Collection of Formulas for Water Pressure and Moments in Submerged Beams. D. N. Showalter. Collects in convenient form some of the formulas used by a designer of hydraulic work. 1200 w. Eng News—May 27, 1909. No. 5020.

We supply copies of these articles. See page 723.

Irrigation.

Proposed Construction of the Porto Rico Irrigation Service. B. M. Hall. A statement of the South Coast Irrigation Project in Porto Rico. Ills. 1600 w. Eng News—May 27, 1909. No. 5018.

See also Hydro-Electric, under ELECTRICAL ENGINEERING, GENERATING STATIONS.

Italy.

Water Supply Projects for Apulia (Die Wasserversorgungs-Anlage für Apulien). Dr. Brandau. An outline of a very large water-supply scheme for this district in Italy. Serial, 1st part. 1800 w. Deutsche Bau—April 10, 1909. No. 4874 B.

Pipe Lines.

Perturbations Produced by the Closing of Gate Valves in Water Pipe Lines (Perturbations produites par la Fermeture des Robinets-Vannes sur le Fonctionnement d'une Distribution d'Eau). Henry Dide. Theoretical and mathematical. Ills. 4000 w. Génie Civil—April 24, 1909. No. 4842 D.

See also Drainage Canals, under MUNICIPAL; and Pipe Lines, under MECHANICAL ENGINEERING, HYDRAULIC MACHINERY.

Pipes.

The Design of Reinforced-Concrete Pipes to Withstand Compression and Bending (Calcul des Tuyaux en Béton armé soumis à des Efforts de Compression et de Flexion). P. Caufourier. Mathematical. 2600 w. Génie Civil—April 3, 1909. No. 4836 D.

Purification.

The Practical Sterilization of Water and of Sewage Effluents. Read before the Inst. of Munic. Engrs., London. H. C. H. Shenton. Considers the evidence for and against sterilization, the methods and costs. 4500 w. Surveyor—May 7, 1909. Serial, 1st part. No. 4704 A.

Reservoirs.

World's Largest Covered Reservoir. An account of the opening of the Honor Oak reservoir. Ills. 1500 w. Surveyor—May 7, 1909. No. 4705 A.

Stream Flow.

A Graphic Solution of Kutter's Formula. L. I. Hewes and Joseph W. Roe. Gives a graphic solution of interest to those who deal with canals, flumes and streams. Diagram. 500 w. Bul Am Inst of Min Engrs—May, 1909. No. 5001 F.

Stream Gauging.

See same title, under MEASUREMENT.

Tanks.

The Design of Elevated Tanks and Stand-Pipes. Discussion of the paper by C. W. Birch-Nord. 3000 w. Pro Am Soc of Civ Engrs—May, 1909. No. 5109 E.

Typhoid.

Typhoid Fever and Water-Supply Statistics for 48 New York Cities. Tabulated statistics with a general discussion. 2000 w. Eng News—May 27, 1909. No. 5022.

Water Towers.

A Unique Water Tower. Edward P. Bailey. Illustrated description of a reinforced-concrete tower 185 feet high in the San Bernardino Mts., California. 900 w. Munic Engng—May, 1909. No. 4548 C.

See also Tanks, under WATER SUPPLY.

Water Works.

Water Supply. Muir Edwards. Read at convention of Union of Alberta Municipalities. Outlines the main features of a public supply, discussing the uses, quality, sources of supply, and method of distribution. 4000 w. Can Engr—May 14, 1909. No. 4673.

A Brief Description of the Cambridge Water Works. History and illustrated description. 3000 w. Harvard Jour of Engng—April, 1909. No. 4932 D.

Cowlyd Water-Works. Describes the old and new works. Ills. 2500 w. Surveyor—April 23, 1909. No. 4454 A.

See also Pumping Plants, under MECHANICAL ENGINEERING, HYDRAULIC MACHINERY.

Weirs.

Weir Measurements (Jaugeages par Déversoirs). F. Roussillon. Gives two curves for determining coefficients for free and submerged weirs. Ills. 2000 w. Tech Mod—April, 1909. No. 4831 D.

Valves.

Recent Reinforced Concrete Weir Construction (Neuere Wehrbauten aus Eisenbeton). F. W. Otto Schulze. Illustrated description and discussion of various structures. Serial, 1st part. 2800 w. Beton u Eisen—April 2, 1909. No. 4895 F.

Hydraulic Gate Valves for the Chicago Water-Works. Brief illustrated description. 700 w. Eng News—May 13, 1909. No. 4648.

WATERWAYS AND HARBORS.

Baltimore.

Baltimore's Municipal Dock Improvements. William H. Stone. An illustrated description of work to improve the port facilities. 2500 w. Mfrs' Rec—May 27, 1909. No. 5008.

Calumet River.

See Great Lakes, under WATERWAYS AND HARBORS.

Canals.

The Proposed National Ship Canal in Scotland. Maps with descriptive account of a proposed ship canal from the North Sea to the Atlantic sea-board. 3000 w. Engng—April 23, 1909. No. 4463 A.

Progress in Inland Navigation. Editorial on conditions and work in progress in different countries. 1800 w. Engng—May 7, 1909. No. 4727 A.

The Crossing of Rivers at Constant Level by Navigable Canals (Sull' Attra-

versamento, a Livello costante, dei Fiumi con Canali navigabili). Mario Majocchi. A discussion of various arrangements. Ills. 3000 w. Monit Tech—April 10, 1909. No. 4846 D.

Docks.

Immingham Docks. Illustrated description of the extensive new dock works of the Great Central Ry. Co., on the Humber River. Also editorial. Plate. 5000 w. Engng—May 14, 1909. Serial, 1st part. No. 4959 A.

Dry Docks.

The Graving Docks of the World. N. G. Gedye. This first article of a series deals principally with the graving docks of Great Britain, discussing size. 2000 w. Engr, Lond—April 30, 1909. Serial, 1st part. No. 4629 A.

Great Lakes.

The Effect of the Proposed Calumet Canal on the Levels of the Great Lakes. Reports the testimony given in the case before the U. S. Courts in regard to a proposed canal which will reverse the flow of the Calumet River and so lower the level of Lake Michigan. 2500 w. Eng News—May 27, 1909. No. 5019.

Locks.

Lock No. 3, Cumberland River. William W. Harts. An illustrated description of this work, with costs. 1000 w. Eng News—May 6, 1909. No. 4523.

Niagara River.

Review of the Report of William Spencer on the Physics of the Niagara River. Isham Randolph. A critical review with suggestions. 5800 w. Can Engr—May 21, 1909. No. 4917.

Panama Canal.

The Type of the Panama Canal. C. E. Grunsky. An illustrated review of the proceedings that led to the selection of the lock-type. 9000 w. Pop Sci M—May, 1909. No. 4405 C.

Piers.

New Municipal Piers in Baltimore Harbor. Illustrated detailed description of six large piers with wide slips, especially dealing with piers 4, 5, and 6, of steel and concrete construction. 3500 w. Eng Rec—May 8, 1909. No. 4571.

Portland, Ore.

The Harbor of Portland, Oregon. H. Cole Estep. First of a series of articles illustrating and describing the harbors of Portland, Seattle, Tacoma, Vancouver and Victoria. 3000 w. Marine Rev—May, 1909. No. 4681.

Stream Gauging.

See same title, under MEASUREMENT.

Suez Canal.

The Present Condition of the Suez Canal. Refers to improvements made in the canal since its opening in 1869, and gives a brief description of the present condition. 1500 w. Engr, Lond—April 30, 1909. No. 4628 A.

Tennessee River.

The Improvement of Our Waterways; With Special Reference to the Tennessee River. James Nisbet Hazlehurst. An account of the futility of work costing over seven and a half millions. 3000 w. Eng News—May 6, 1909. No. 4522.

U. S. Waterways.

The Waterways of the United States: Actual Expenditures and Results to Navigation and Commerce. Alexander H. Weber. Aims to show the actual facts in the case as derived from a careful analysis of the records. Also editorial. 5000 w. Eng News—May 6, 1909. No. 4520.

Water Powers.

Review of the Water-Powers of South Carolina—Developed and Undeveloped. S. Mays Ball. A study of the river systems and the known water powers. 3500 w. Elec Rev, N Y—May 8, 1909. No. 4582.

Government Control of Water-Power Utilization in Switzerland (Schweizerische Bundesgesetzgebung über Ausnutzung der Wasserkräfte). Dr. E. Frey. An outline and discussion of the regulations. Serial, 2 parts. 3700 w. Schweiz Bau—April 17 and 24, 1909. No. 4876, each B.

Wharves.

The Construction of a Concrete Mass and Block-Work Quay Wall by Helmet Divers in Open Water. John Taylor. Describes a wall built at Portland Harbor, England. Ills. 5000 w. Can Soc of Civ Engrs—April 29, 1909. No. 4553 N.

MISCELLANY.

Drawings.

Copyright in Drawings of a Technical Character. D. A. Usina. Brief discussion of the new law to go in effect July 1, 1909, in the United States. 1500 w. Pro Am Soc of Civ Engrs—May, 1909. No. 5106 E.

Forestry.

Forestry Operations About the Wachusett Reservoir. Notes from a paper by E. R. B. Allardice, describing the methods followed in maintaining the wood lots and planting the unforested portion of the reservation. 1700 w. Eng Rec—May 15, 1909. No. 4692.

Ice.

Hauling a Contractor's Plant Across the Ice on the Hudson River. Describes methods used in taking the larger part of a plant on the N. Y. State barge canal across the Hudson, giving the bearing power of ice ten inches thick. 1000 w. Eng News—May 20, 1909. No. 4783.

Landslides.

The Salette Landslide of 1908 and Some Earlier Quebec Landslides. Describes five slides in Quebec, and also slides in British Columbia. 3500 w. Eng News—May 27, 1909. No. 5021.

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ELECTRICAL ENGINEERING.

COMMUNICATION.

Radio-Telegraphy.

Wireless Telegraphy (La Télégraphie sans Fil). M. Ferrié. A review of the theory and present state of wireless communication. Ills. 4800 w. Ann d Ponts et Chaussées—1909-I. No. 4810 E + F.

Fundamental Principles in the Design of Spark-Telegraphy Stations. Dr. F. Kiebitz. Abstract from *Elektrotechnische Zeit.* Reviews the developments that have led to the improved results. 1000 w. Elect'n, Lond—April 30, 1909. No. 4604 A.

Transatlantic Wireless Telegraphy. G. Marconi. From a discourse delivered at the Royal Inst. Describes results and observations recorded during a series of tests made to prove that wireless telegraphy across the Atlantic was possible as a means of commercial communication. Ills. 4000 w. Nature—April 22, 1909. Serial, 1st part. No. 4441 A.

A New System of Wireless Telegraphy Used by the Telefunken Company, Count Arco. Describes a system which is a compromise between the "spark" and the "arc" systems. 3000 w. Elect'n, Lond—April 30, 1909. No. 4603 A.

The Lepel System of Wireless Telegraphy. Illustrates and describes the working parts of the Lepel apparatus. 1000 w. Elect'n, Lond—May 14, 1909. No. 4946 A.

Radio-Telephony.

Wireless Telephony (Telefonia elettrica senza Fili). O. Majorana. A discussion of the Poulsen system of wireless telephony. Ills. 2500 w. Elettricita—April 15, 1909. No. 4845 D.

Telephone Cables.

Some Considerations in the Manipulation of Dry-Core Telephone Cables. F. G. C. Baldwin. Abstract of paper before the Birmingham Sec. of the Inst. of Elec. Engrs. Considers telephone practice, describing operations and methods to secure working efficiency. 1800 w. Elec Engr, Lond—April 23, 1909. Serial, 1st part. No. 4446 A.

Location of Faults in Cables. H. Mauradian. Discusses the correction of the Murray loop test, giving formula. Also editorial. 800 w. Elec Wld—May 13, 1909. No. 5040.

DISTRIBUTION.

Buffalo, N. Y.

Electricity in Buffalo, N. Y. George J. Kirchgasser. Information in regard to the distribution and the extensive use made of electricity brought from Niagara Falls. 3000 w. Elec Wld—May 6, 1909. No. 5031.

DYNAMOS AND MOTORS.

A. C. Dynamos.

The Function of the Damping Device in the Parallel Operation of Alternating Current Machines (Die Wirkung des Dämpfers bei parallel arbeitenden Wechselstrommaschinen). Iwan Dory. Ills. 2800 w. Elektrotech u Maschinenbau—April 4, 1909. No. 5066 D.

A. C. Motors.

Alternating Current Electric Motors Snowden B. Redfield. Illustrates and describes the distinguishing features of construction, characteristics of operation, and uses of the squirrel cage, slip ring induction and synchronous motors. 2000 w. Am Mach—Vol. 32. No. 18. No. 4518.

Vector Diagram for Changing Pole Connections on Three-Phase Motors (Vektordiagramme für Drehstrommotoren mit Polumschaltung). Herr Schnackenburg. Illustrated discussion. 1200 w. Elek Kraft u Bahnen—April 14, 1909. No. 5063 D.

A New Six-Speed Motor, and the Application of Multi-Speed Motors to Cloth Pressing Machines (Neuer sechstufiger Motor und die Verwendung der Stufenmotoren zum Antrieb von Stoffdruckmaschinen). O. Knöpfli. Illustrated description. Serial, 1st part. 2500 w. Elek Kraft u Bahnen—Feb. 4, 1909. No. 4802 D.

A. C. Turbo-Generators.

See Turbine Tests, under MECHANICAL ENGINEERING, STEAM ENGINEERING.

Commutation.

Commutation Phenomena. Carlton L. Kennedy. Diagrams and explanation of what is happening during commutation. 1500 w. Elec Wld—April 22, 1909. No. 4439.

Commutators.

Turbo-Commutators. R. J. Roberts. Discusses points in their design and construction. 2200 w. Elect'n, Lond—May 7, 1909. No. 4719 A.

Cooling.

The Advantages of Forced Draft in Generators and Motors. Alex. Churchward. Detailed discussion of the advantages to be gained. 1000 w. Elec Wld—May 13, 1909. No. 5039.

D. C. Motors.

Location and Repair of Troubles in Direct Current Motors. R. H. Fenkhausen. Gives tests for locating and directions for speedy repairs. Ills. 1500 w. Power—May 11, 1909. No. 4585.

Auxiliary Poles for Direct-Current Machines. John N. Dodd. Discusses their

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electrical design and method of testing. Diagrams. 4500 w. Pro Am Inst of Elec Engrs—May, 1909. No. 4999 F.

The Series Motor as a Load Equalizer (Ausgleich von Belastungsstossen mittels einer Reihenschlussmaschine). Thomas Rosskopf. Mathematical. Ills. 1500 w. Elek Kraft u Bahnen—April 24, 1909. No. 5064 D.

Flux Density.

A Graphical Method for Determining the Flux Density in Teeth. F. Blanc Abstract translation from *Elek. Zeit.* Shows the limitations of ordinary methods and describes the graphical method of determining the required ampere-turns. 1200 w. Elect'n, Lond—April 23, 1909. No. 4451 A.

Induction Motors.

Torque and Speed Relations in Polyphase Induction Motors. A. S. McAllister. Gives a diagram which represents the complete performance of an induction motor, discussing the effect upon the torque of changing the secondary resistance of a motor without altering the design proportions. 1200 w. Elec Wld—April 22, 1909. No. 4438.

The Effect of the Starting Characteristics Upon the Operation of an Induction Motor. M. Berthold. Outlines the changes in design proportion that affect the torque relations, with particular reference to the polyphase squirrel-cage type of machine. 2000 w. Elec Wld—April 22, 1909. No. 4437.

The Application of the No-Load and Short-Circuit Diagram to the Design and Testing of Induction Motors. Stanley P. Smith. Describes a diagram by means of which the efficiency, torque, power factor, slip, etc., can be accurately determined. 3000 w. Elect'n. Lond—May 7, 1909. Serial. 1st part. No. 4720 A.

Railway Motors.

Notes on the Single-Phase Railway Motor. S. M. Kintner. Briefly considers its operation on direct and on alternating current. 1200 w. Elec Jour—May, 1909. No. 4547.

Rheostats.

Submerged Wire Rheostat. P. M. Brown. Gives formulae found reliable for immersed wire rheostats using ordinary galvanized iron wire as a resistor. Ill. 800 w. Elec Wld—May 6, 1909. No. 5035.

Starters.

Recent Practice in the Design of Motor Starters. Illustrates and describes recent designs. 1000 w. Prac Engr—May 14, 1909. Serial, 1st part. No. 4948 A.

Turbo-Generators.

Turbo-Generators (Les Turbogénératrices). An abstract of a paper by M. J. Frankfourte outlining the present status of their design. Ills. 3500 w. Elecn—April 17, 1909. No. 4825 D.

Windings.

Repairing a Damaged Armature Winding. R. H. Fenkhausen. Illustrated description of methods. 1000 w. Power—May 4, 1909. No. 4488

ELECTRO-CHEMISTRY.

Corrosion.

Corrosion of Iron and Steel. Edward Crowe. Abstract of paper before the Cleveland Inst. of Engrs. Considers some of the circumstances and conditions under which relative rates of corrosion take place. 1800 w. Engr, Lond—April 23, 1909. No. 4472 A.

ELECTRO-PHYSICS.

Cells.

Experiments on the Current and Energy Efficiencies of the Finlay Electroyltic Alkali-Chlorine Cell. F. G. Donnan, J. T. Barker, and B. P. Hill. Abstract of a paper read before the Faraday Soc. Describes the main features and gives particulars of efficiency tests. Ills. 2000 w. Elect'n, Lond—April 30, 1909. No. 4602 A.

Condensers.

The Effect of an Air-Blast Upon the Spark Discharge of a Condenser Charged by an Induction Coil or Transformer. J. A. Fleming and H. W. Richardson. Abstract of a paper before the Phys. Soc. The discharge current is shown to be more regular and the resonance more accurately delineated. 1500 w. Elect'n, Lond—May 14, 1909. No. 4947 A.

Conductivity.

Conductivity and the Valuation of Electric Conductors. E. F. Northrup. A statement of accepted definitions of conductivity and the necessary relations which follow, with a brief account of how conductivity may be measured. 6000 w. Elec-Chem & Met Ind—May, 1909. No. 4506 C.

Self-Induction.

A Graphical Study of Self-Induction. F. P. McDermott, Jr. Discusses the application of a graphic method to problems connected with the rise of current in a circuit possessing resistance and inductance under the application of a steady e. m. f. 1500 w. Elec Wld—May 20, 1909. No. 5042.

Waves.

The Resolution of Periodic Curves into their Harmonic Waves (Ueber die Zerlegung periodischer Kurven in ihre harmonischen Wellen). J. Fischer Hinnen. Mathematical. Ills. 4500 w. Elektrotech u Maschinenbau—April 11, 1909. No. 5067 D.

GENERATING STATIONS.

Accumulators.

The Storage Battery. A. Wohlgemuth. Explains both the Planté and Faure types, and matters relating to their use. Ills. 1500 w. Power—May 25, 1909. No. 4979.

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The Installation and Care of Storage Batteries. Omer F. Dubruiel. Directions for installing, care, charging, etc. 3000 w. Elec Wld—May 6, 1909. No. 5034.

Central Stations.

The Rating and Cost of Steam Electric Generating Stations. H. M. Hobart. An investigation. 1200 w. Elec Rev, Lond—May 7, 1909. Serial. 1st part. No. 4667 A.

Economies of Medium-Sized Power Stations. A. J. J. Pfeiffer. A study of comparisons between steam, gas, and oil engines. Ills. 4000 w. Inst of Elec Engrs—May, 1909. No. 4943 N.

The Supply of Electrical Energy for Power Purposes in Connection with Traction Supply Systems. Arthur Imbery. Explains methods of feeding traction circuits, and of supplying consumers, and the precautions necessary to comply with the Board of Trade regulations. Diagrams. 2200 w. Elec Rev, Lond—April 23, 1909. Serial. 1st part. No. 4447 A.

Low-Voltage Equipment and Control in Waterside Station No. 2 of the New York Edison Company. Illustrated detailed description. 2500 w. Elec Wld—April 8, 1909. No. 4430.

System of the Lockport Light, Heat and Power Company. Outlines the history and gives illustrated description of stations. 2500 w. Elec Wld—May 6, 1909. No. 5029.

Walthamstow Electricity Station. Illustrates and describes the installation of a steam plant in England. 2000 w. Tram & Ry Wld—May 6, 1909. No. 4953 B.

The Cap Pinède Station of the Marseilles Electric Company (Usine électrique de la Cie d'Electricité de Marseille au Cap Pinède). Illustrated description. 3000 w. Génie Civil—April 17, 1909. No. 4838 D.

Costs.

Relation of Load Factor to Power Costs. Papers on this subject by E. W. Lloyd, C. A. S. Howlett, and J. M. S. Waring, discussed together. 9500 w. Jour W Soc of Engrs—April, 1909. No. 4789 D.

Design.

Discussion on "Prime Movers," New York, February 19, 1909. Gives the discussion of papers by Charles P. Steinmetz. 7000 w. Pro Am Inst of Elec Engrs. May, 1909. No. 4995 F.

Hydro-Electric.

The Utilization of Water Powers (La Houille blanche, Installation et Utilisation des Chutes d'Eau). Achille Bergès. Refers particularly to the problems of France. Serial. 1st part. 4000 w. Elecn—April 10, 1909. No. 4824 D.

Hydro-Electric Power in Canada. Cecil B. Smith. A review of the progress in developing water-powers, describing the conditions, topography, etc. Maps. 14000 w. Pro Am Soc of Civ Engrs—May, 1909. No. 5107 E.

The High Head Hydro Electric Development at Loch Leven, Scotland. J. Murray S. Culbertson. Plan, and illustrated detailed description of the new plant for the British Aluminum Co. 3000 w. Eng Rec—May 1, 1909. No. 4388.

Swedish Hydro-Electric Power-Plants. John George Leigh. An illustrated review of the development of the hydraulic power of Scandinavia. 4500 w. Cassier's Mag—May, 1909. No. 4403 B.

Lages River Hydraulic Development Near Rio de Janeiro. Describes this recent development in Brazil. 2000 w. Eng Rec—May 22, 1909. No. 4928.

The Hydro-Electric Power Plant of the Rio de Janeiro Tramway, Light, & Power Company. L. L. Perry. Illustrated description of this hydro-electric plant in Brazil. 3000 w. Elec Wld—May 6, 1909. No. 5037.

Sewalls Falls Plant Near Concord, N. H. S. Rice. Illustrated description of a 2000-k.w. water power plant containing the first installation of vertical multi-runner direct-connected open-flume turbine. 2500 w. Power—May 25, 1909. No. 4978.

Divided-Fall Hydro-Electric Developments on the Hoosic River. An illustrated account of a development of unusual interest because of the duplex plant found necessary. 2500 w. Elec Wld—May 20, 1909. No. 5041.

Non-Attendance Electrical Plant at Westfield, Mass. Brief illustrated description of an almost automatic plant which has been in operation about six years. 800 w. Elec Wld—May 20, 1909. No. 5043.

A Low-Head Hydro-Electric Development, Near Escanaba, Mich. Brief illustrated description. 1500 w. Eng Rec—May 15, 1909. No. 4696.

Sioux Falls Hydro-Electric Development. Illustrated description of a plant in South Dakota for a city of about 16,000 inhabitants. 1500 w. Elec Wld—April 22, 1909. No. 4435.

Stanislaus River Electric Power Development. O. M. Boyle, Jr. Illustrated description of this project in California. 3500 w. Cal Jour of Tech—April, 1909. No. 4759.

Water Power and Irrigation in Southwestern Colorado. F. Parkman Coffin. Describes the hydro-electric developments of the Telluride Power Co., and the Animas Power & Water Co. Ills. 2500 w. Harvard Jour of Engng—April, 1909. No. 4931 D.

Isolated Plants.

The Electrical Equipment of the Gorham Manufacturing Company. C. E. Fairbanks. Illustrated description of the equipment of an industrial plant having varied requirements for the use of electricity. 2000 w. Elec Wld—May 6, 1909. No. 5030.

Interconnections of Electrical Equipment of Indiana Steel Company, Gary, Ind. Outlines the arrangement of the gen-

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erating equipment and auxiliary machinery, and gives plan and description of the switchboard. 2500 w. Elec Wld—May 13, 1909. Serial. 1st part. No. 5038.

Rates.

Equity v. Expediency—A Tariff Question. Ernest E. Sharp. A discussion of the two-rate system. 1400 w. Elec Rev, Lond—April 23, 1909. No. 4449 A.

Switchboards.

High-Tension Switchboards with Removable Switch Carriages. Illustrated detailed description. 1500 w. Ir & Coal Trds Rev—April 23, 1909. No. 4474 A.

See also Isolated Plants, under GENERATING STATIONS.

LIGHTING.

Arc Lamps.

The Regulation of Alternate-Current Flame Arc Lamps. Paul Högner. Abstract from *Electrotechnische Zeit.* Calls attention to the importance of the resistance variations, and to the fact that the use of choking coils improves the efficiency nearly 40 per cent. 1000 w. Elect'n, Lond—May 14, 1909. No. 4945 A.

Automobile.

See Lighting, under MECHANICAL ENGINEERING, AUTOMOBILES.

Hand Lamps.

Lighting the Inside of Freight Cars during Loading (Innenbeleuchtung von Güterwagen während des Ladegeschäftes). D. Lasser. Describes electric hand lamps for connection with sockets set at intervals under the edge of the freight platform, etc. Ills. 2700 w. Glasers Ann —April 15, 1909. No. 5058 D.

Illumination.

The Theory and Practice of Illumination. Thomas W. Rolph. Discusses the purpose of illumination, the protection of the eye, the development of the science of illumination, and related subjects. 5000 w. Jour Fr Inst—May, 1909. No. 4762 D.

Incandescent Lamps.

Experience with High-Efficiency Lamps in Industrial Plants. Warren H. Miller. Describes efforts made to use high-efficiency lamps in a big oil plant, showing the destruction to both tantalum and tungsten lamps when exposed to vibration. Also editorial. 3000 w. Elec Wld—May 6, 1909. No. 5032.

See also Tantalum, under MINING AND METALLURGY, MINOR MINERALS.

Signal Lamps.

Electric Lighting of Railway Signal Lamps. A discussion of the advantages and methods. Ills. 1800 w. Elec Engr, Lond—May 7, 1909. No. 4716 A.

Street.

Comparison of Gas Arcs, Flame Arcs and Series Tungsten Arches for Business-District Street-Lighting. H. W. Hillman. Favors the tungsten arch system. 1000 w. Elec Wld—April 22, 1909. No. 4440.

Viaduct Lighting in Kansas City. Edwin R. Weeks. Describes the lighting by the tantalum lamp. 1600 w. Elec Wld—April 8, 1909. No. 4434.

Train.

See Train Lighting, under RAILWAY ENGINEERING, MOTIVE POWER AND EQUIPMENT.

MEASUREMENT.

Dielectric Strength.

The Measurement of the Insulation Resistance of a Live Three-Wire System. Gisbert Kapp and Dennis Coales. Abstract of paper accepted by the Inst. of Elec. Engrs. Describes methods of finding the joint fault resistance, and a method whereby the insulation of each wire may be ascertained separately. 1000 w. Elect'n, Lond—May 7, 1909. No. 4721 A.

Galvanometers.

Calibration of a Ballistic Galvanometer. C. M. Jansky. Points out the fallacy of methods given in some handbooks, and the reason for the inaccuracy. 500 w. Elec Wld—April 8, 1909. No. 4431.

High-Frequency Currents.

Apparatus for the Measurement of Telephone Currents and, in General, All Weak Currents of Very High Frequency (Appareil pour la Mesure des Courants téléphoniques et, en Général, des Courants périodiques de grande Fréquence et de tres faible Intensité). Riccardo Arno. Illustrated description. 3500 w. Bul Soc Int des Elecns—April, 1909. No. 4816 F.

Insulation Testing.

The Use of Dielectrics and the Principal Tests Applied to Them. T. Germann and S. M. Hills. Extract of paper read before the Jun. Inst. of Engrs. Discusses the properties of insulating materials and the necessary tests, giving particulars of a new method of testing. 3300 w. Elect'n, Lond—May 14, 1909. No. 4944 A.

See also Dielectric Strength, under MEASUREMENT.

Meter Testing.

Tests of Watt-Hour Meters. Report prepared by Dr. Cary T. Hutchinson on tests of direct and alternating-current watt-hour meters of the type used in New York City. 3000 w. Elec Wld—April 29, 1909. No. 4486.

Motor Testing.

A Special Brake and Mechanism for Recording the Mechanical Output of a Motor. A. H. Forman. Illustrates and describes an apparatus which gives quite accurate results. 1500 w. Sibley Jour of Engng—April, 1909. No. 5103 C.

See also Induction Motors, under DYNAMOS AND MOTORS.

We supply copies of these articles. See page 723.

POWER APPLICATIONS.

Air Compressors.

See Air Compressors, and Turbo-Compressors, under MECHANICAL ENGINEERING, POWER AND TRANSMISSION.

Elevators.

See same title, under MECHANICAL ENGINEERING, TRANSPORTING AND CONVEYING.

Heating.

Notes on Radiators. Gives tabulated results of experiments to determine the efficiency, with related information. 1800 w. Elec Rev, Lond—May 7, 1909. No. 4668 A.

Machine Tools.

See Electric Driving, under MECHANICAL ENGINEERING, POWER AND TRANSMISSION.

Ships.

See Electric Power, under MARINE AND NAVAL ENGINEERING.

TRANSMISSION.

High Tension.

High Tension Transmission. Percy H. Thomas. Discusses the feasibility, earning power, and design of an adequate plant. 6000 w. Pro Am Inst of Elec Engrs—May, 1909. No. 4992 F.

Lightning Protection.

Lightning Arresters. David B. Rushmore. Read at meeting of Cent. Elec. Ry. Assn. Describes some recent developments. 3500 w. Sci Am Sup—May 22, 1909. No. 4904.

Guard Wires on Transmission Lines. Max H. Collbohm. Discusses their value as a protection from lightning. 800 w. Elec Wld—May 20, 1909. No. 5044.

Line Design.

The Crossing of Railways by Transmission Lines (Considerazioni sul Sistema a tre Tesate di doppi Conduttori cordati adottato per gli Attraversamenti superiori delle Ferrovie). Manfredo Fasella. A discussion of the new standards of the Italian government. Ills. 2500 w. Ing Ferro—April 16, 1909. No. 4851 D.

Line Failures.

The Failure of a Portion of a Steel Tower Electric Transmission Line in California. Edwin Duryea, Jr. An illustrated description of the line and its partial failure during a severe storm. 1700 w. Eng News—May 13, 1909. No. 4646.

Lines.

Joint Pole Lines in Los Angeles. J. E. Macdonald. Explains the causes of the pole nuisance in California, and the combinations adopted to improve conditions. Ills. 700 w. Elec Wld—April 22, 1909. No. 4436.

Motor Converters.

The Theory and Application of Motor Converters. H. S. Hallo. Describes the principle, operation, design, and characteristics of motor converters, referring to arrangements necessary when used on three-wire and traction systems. Ills. 6000 w. Inst of Elec Engrs—April, 1909. No. 4713 N.

Poles.

Reinforced Concrete in Electrical Transmission Lines. Illustrated description of methods of making reinforced-concrete poles, and explanation of the advantages claimed. 3500 w. Elec Age—April, 1909. No. 4485.

Protective Devices.

The Protection of Electrical Plants against Excess Voltages (Contributo allo Studio sulla Protezione degli Impianti elettrici contro le Sovratensioni). Gino Campos. Reviews the requirements of protective devices and the principles on which they are designed. Ills. 3500 w. Industria—April 11, 1909. No. 4848 D.

Rotary Converters.

The Kolben-Seidener Converter (Periodenumformer System Kolben-Seidener). August Bloch. A description and discussion of this machine. Ills. 4000 w. Elektrotech u Maschinenbau—April 18, 1909. No. 5068 D.

Transformers.

Transformers. H. B. Gear and P. F. Williams. Explains the laws governing the design of the transformer, the types of windings and core used, discussing matters relating to efficiency, etc. Ills. 5000 w. Elec Age—April, 1909. No. 4484.

Parallel Operation of Transformers. J. B. Gibbs. Shows the method of determining the division of the load between the transformers and the importance of attending to characteristics of transformers to be connected. 2000 w. Elec Jour—May, 1909. No. 4545.

Voltage Regulation.

Discussion on "Conditions Affecting Stability in Electric Lighting Circuits," New York, Jan. 8, 1909. The paper by Elihu Thomson is discussed. 2500 w. Pro Am Inst of Elec Engrs—May, 1909. No. 4997 F.

The Tirrill System of Voltage Regulation for Single- and Three-Phase Generators (Régulateur automatique de Tension pour Génératrices monophasées et triphasées Système Tirrill). C. Waldschmidt. Describes and discusses the principle of the Tirrill regulator and its working. Ills. 5000 w. Soc Belge d'Elecns—April, 1909. No. 4814 E.

Wire Joints.

Wire Joints for Transmission Lines (Ueber Drahtbundverfahren für Freileitungen). Robert Nowotny. A review of developments since the invention of the Arld joint. Ills. Serial. 1st part. 1200 w. Elektrochem Zeitschr—April, 1909. No. 4854 D.

We supply copies of these articles. See page 723.

INDUSTRIAL ECONOMY.

Accounting.

Industrial Accounting (Les Techniciens de la Comptabilité). Maurice Bellom. Discusses the training of accountants in various countries. Serial. 1st part. 5000 w. Tech Mod—April, 1909. No. 4832 D.

Distribution of Indirect Costs by the Machine Hour Method. Gershom Smith. Outilnes the application of the machine hour to the distribution of indirect cost, to determine correct rates. 3500 w. Engineering Magazine—June, 1909. No. 4987 B.

Apprenticeship.

Apprenticeship by the School and by the Shop (L'Apprentissage par l'Ecole et par l'Atelier). E. Labbe. A discussion of conditions in France, favoring trade-school instruction. Serial. 1st part. 2500 w. Tech Mod—April, 1909. No. 4833 D.

Cost Systems.

A System of Distributing Waste Losses in Raw Material to the Cost of Finished Products. L. W. Olsen. Indicates a method of distributing losses occurring in the melting and mixing of non-ferrous metals. 2000 w. Am Brass Found Assn—May 18, 1909. No. 5113 N.

Education.

The Progress of Engineering Education. Robert W. Rogers. Gives an outline of the history of the development of structural engineering from its beginning to the present day. 7500 w. Sibley Jour of Engng—April, 1909. No. 5104 C.

Dedication of the Swift Engineering Building at Northwestern University. Addresses made by John F. Hayford, and Charles Whiting Baker. Ills. 6500 w. Eng News—May 20, 1909. No. 4775.

The Hammond Mining and Metallurgical Laboratory. Louis D. Huntoon. Illustrates and describes the building and its equipment given by Prof. John Hays Hammond to the Sheffield Scientific School of Yale University. 2500 w. Yale Sci M—May, 1909. No. 4750 C.

The University of Birmingham. Illustrated description of the mining equipment and training. 4000 w. Col Guard—April 23, 1909. No. 4458 A.

Secondary Mining Schools in Austria. Herman Löcker. Explains the organization, method of support, and subjects taught in these schools, located in each mining district. 2000 w. Mines & Min—May, 1909. No. 4483 C.

Eight-Hour Day.

The Eight-Hour Day in Practice. Considers the probable effect of the English Act that goes into operation July 1st in the collieries. 2500 w. Col Guard—May 7, 1909. No. 4724 A.

Engineers.

Why Engineers Do Not Take More Part in Government. Joseph R. Worcester. Addresses at meeting of Boston Society of Civil Engineers. 6000 w. Jour Assn of Engng Socs—March, 1909. No. 4907 C.

Fire Loss.

See Natural Resources, under INDUSTRIAL ECONOMY.

Labor.

The Unemployed in European Countries. W. D. P. Bliss. Information and discussion from a bulletin issued by the American Bureau of Labor. Considers what European countries have accomplished, and the work in progress. 5000 w. Ir & Coal Trds Rev—May 7, 1909. Serial. 1st part. No. 4731 A.

Labor Insurance.

The Insurance and Pensioning of Employés in Austria. An examination of the three Austrian Acts of Parliament which deal with these matters. 4500 w. Engng—April 30, 1909. No. 4623 A.

Management.

See Steel Works, under MINING AND METALLURGY, IRON AND STEEL; and Management, under RAILWAY ENGINEERING, MISCELLANY.

Marine Transport.

Japanese Shipping and Ship-Building Subsidies. A discussion of the new law enacted by the Diet which makes the amount payable in subsidies less than during the past year or two. 1200 w. Engng—April 30, 1909. No. 4621 A.

Natural Resources.

Introductory Address at Meeting of Engineers in New York, March 24, 1909. Dr. James Douglas. 1200 w. Bul Am Inst of Min Engrs—May, 1909. No. 5004 F.

Conservation of Natural Resources. Jas. Douglas. A review of recent progress in copper smelting, blast-furnace practice, and other industries. 5500 w. Bul Am Inst of Min Engrs—May, 1909. No. 5000 F.

The Conservation of Natural Resources by Legislation. R. W. Raymond. Discusses some of the dangers of legislative conservation, and related matters. 6500 w. Bul Am Inst of Min Engrs—May, 1909. No. 5006 F.

The Conservation of Water. John R. Freeman. Discusses some misapplications of the doctrine of forest influence on stream flow, and other features of the conservation movement. 5000 w. Bul Am Inst of Min Engrs—May, 1909. No. 5005 F.

We supply copies of these articles. See page 723.

A Rational Basis for the Conservation of Mineral Resources. Joseph A. Holmes. Discusses the proper basis for such conservation, what may be accomplished, etc. 3000 w. Bul Am Inst of Min Engrs—May, 1909. No. 5003 F.

The Waste of Our Natural Resources by Fire. Charles Whiting Baker. Discusses statistics of waste due to fires. 2000 w. Bul Am Inst of Min Engrs—May, 1909. No. 5007 F.

Electricity and the Conservation of Energy. Lewis B. Stillwell. Read at a joint meeting of Engineering Societies held in New York, March 24, 1909. Illustrates the function of electricity in the conservation of natural resources, summarizing the present power requirements in the United States, and the water power available, and related matters. Also discussion. 9000 w. Pro Am Inst of Elec Engrs—May, 1909. No. 4993 F.

Patents.

The Patent Situation. Gorham Crosby. A criticism of statements made by James T. Barkelew in regard to the United States patent laws. 1800 w. Elec Wld—April 8, 1909. No. 4433.

The Patent System in Its Relation to Industrial Development. Frederick P. Fish. Calls attention to some of the underlying principles of the United States patent policy, showing how they seem to work in practice. 10000 w. Pro Am Inst of Elec Engrs—May, 1909. No. 4998 F.

Peru.

The Resources of the Peruvian Andes and Amazon. C. Reginald Enock. An interesting description of this country, its natural resources and products. 7000 w. Jour Soc of Arts—April 30, 1909. No. 4595 A.

Tariff.

I. Tariff Revision from the Manufacturer's Standpoint. Dr. A. B. Farquhar, and II. H. E. Miles; III. From the Importer's Standpoint. Francis E. Hamilton. IV. From the Consumer's Standpoint. Jesse E. Orton. V. A Permanent Tariff Bureau. Seymour C. Loomis. Papers presented before the American Association for the Advancement of Science, at Baltimore. 12500 w. Pop Sci M—May, 1909. No. 4406 C.

Wage System.

The Premium System of Paying Workmen. F. C. Blanchard. From a paper before the Nat. Metal Trds. Assn. Describes methods used in lighter manufacturing in the cases of both individual and gang operations. 2000 w. Ir Age—May 6, 1909. No. 4511.

See also Management, under RAILWAY ENGINEERING, MISCELLANY; and Car Maintenance, under STREET AND ELECTRIC RAILWAYS.

MARINE AND NAVAL ENGINEERING.

Armor.

Armor and Projectiles (Corazze e Proietti). E. Bravetta. A discussion of Capt. Tresidder's paper "Modern Armour and its Attack," read before the Inst. of Nav. Archs. Ills. 15000 w. Riv Marit—April, 1909. No. 4843 E + F.

Battleships.

Monster Battleships. Sidney Graves Koon. Discusses the recent increase in size, especially the U. S. vessels of 26000 tons each, to be built at a cost of $9,500,000 per vessel. 1500 w. Int Marine Engng—May, 1909. No. 4493 C.

The World's Seventy Dreadnoughts. Archibald S. Hurd. An illustrated discussion of the struggle for supremacy among naval powers. 4000 w. Cassier's Mag—May, 1909. No. 4400 B.

The French Dreadnoughts. Illustrates and describes particulars of the constructive details, with critical remarks. 1500 w. Engr, Lond—April 30, 1909. No. 4627 A.

The New United States Battleship "Mississippi." Illustrations, with brief description. 800 w. Sci Am—May 29, 1909. No. 5025.

The Brazilian Battleship "Sao Paulo." Illustrated detailed description. Plate. 1700 w. Engng—April 23, 1909. No. 4462 A.

The Speed Trials of the Deutschland Class. Brief comparison of types and designs, especially of the German vessels. 800 w. Engr, Lond—April 23, 1909. No. 4465 A.

Dredges.

Design of Hulls for Hydraulic Cutter Dredges. E. N. Percy. Considers the requirements of a dredge hull. 1700 w. Int Marine Engng—May, 1909. No. 4492 C.

The Bates Electrically Driven Hydraulic Dredger. Illustrated description of a dredge constructed for the Russian government. 600 w. Int Marine Engng—May, 1909. No. 4491 C.

Electric Power.

Electrical Installations on Steamships. H. T. Boothroyd. Abstract of paper read before the Liverpool Engng. Soc. Deals with the wiring and details of the installation, the various uses of electricity and related subjects. 4500 w. Marine Rev—May, 1909. No. 4679.

We supply copies of these articles. See page 723.

French Marine.

The Crisis in the French Marine. A discussion of the country's naval decline as revealed by the recent investigation of M. Picard. 3000 w. Engr, Lond—May 14, 1909. No. 4966 A.

Gas Engines.

Marine Producer Gas Power. C. L. Straub. A comparison of producer-gas and steam equipments. Ills. 3500 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4414 F.

Launching.

Launching Measurements on the Lloyd Steamer "Berlin" at the Weser Company's Yards in Bremen, November 7, 1908 (Stapellaufmessungen beim Ablauf des Lloyddampfers "Berlin" auf der Werft der Aktien-Gesellschaft "Weser" in Bremen am 7 November 1908). Otto Lienau. Results of tests to determine the speed of launching. Ills. 3200 w. Schiffbau—April 14, 1909. No. 4877 D.

Motor Boats.

What the Automobile is Doing for the Boat Engine. Herbert S. Towle. A discussion of the comparative advantages of automobile and marine types. 2500 w. Rudder—May, 1909. No. 4592 C.

Power Boats and Power Boating in the Pacific Northwest. R. M. Haddock. Illustrated descriptions of types in use in a field especially suited to power boat usefulness. 3500 w. Rudder—May, 1909. No. 4590 C.

Propellers.

Origin of the Screw Propeller. Winfield M. Thompson. An account of the Stevens screw-propeller as used in 1804, describing the boat and giving related information. Ills. 8000 w. Rudder—May, 1909. No. 4589 C.

Shipbuilding.

Standardization. Archibald Denny. Read at meeting of the Inst. of Naval Archts. Report on the work done by the Engineering Standards Committee on sections and tests for materials and machinery. 5000 w. Marine Rev—May, 1909. No. 4680.

Shipbuilding on the Great Lakes. Herbert C. Sadler. Read before the Inst. of Naval Archts. Explains the prevailing conditions, and describes features of the modern "Lake freighters." Ills. 3000 w. Engng—May 14, 1909. No. 4965 A.

Ship Resistance.

Researches on the Resistance of Boats to Towing, and a New Speed-Measuring Device (Recherches sur la Resistance à la Traction des Bateaux, un nouveau Mesureur de Vitesses). MM. Barlatier de Mas and Guillet. Illustrated description. 2000 w. Ann d Ponts et Chaussées—1909-I. No. 4812 E + F.

Steamboats.

Jonathan Hulls and His Steamboat. Edward P. Buffet. Sketch of the inventor and description of one of the earliest patented systems of vessel propulsion by means of the steam engine. Ills. 2500 w. Power—May 4, 1909. No. 4487.

Steam Boilers.

Naval Boilers in Service. H. C. Dinger. A review of the relative advantages developed, repairs now necessary, and general economy of the various types of boilers on the vessels of the U. S. fleet that encircled the globe. Ills. 3300 w. Int Marine Engng—May, 1909. No. 4495 C.

Steamships.

Freighters for the A. H. Bull Steamship Company. Illustrated detailed description of a steel freight steamship for foreign trade. 1200 w. Marine Rev—May, 1909. No. 4678.

Triple-Screw Steamer Laurentic. Brief illustrated description of a new vessel for the White Star Dominion service. 1000 w. Engr, Lond—April 23, 1909. No. 4470 A.

See also Shipbuilding, under MARINE AND NAVAL ENGINEERING.

Steam Turbines.

Marine Steam Turbines. Discusses the application of turbines to merchant vessels, examining the advantages claimed, and showing the propeller to be the weak point in the turbine system. 4000 w. Engr, Lond—April 30, 1909. No. 4626 A.

The Manoeuvring Capabilities of Turbine-Driven Vessels. Shows how the turbine-driven vessel is manoeuvred in narrow tidal waterways. Diagram. 1800 w. Engng—April 23, 1909. No. 4460 A.

The Present Development of the Marine Steam Turbine (Die heutige Entwicklung der Schiffsturbine). H. Schmidt. A general review. Serial, 1st part. 3000 w. Zeitschr f d Gesamte Turbinenwesen—April 30, 1909. No. 4882 D.

12,500 H. P. Turbines of the "North Dakota." Illustrated description of the Curtis marine type turbines of 25000 h. p. 2500 w. Power—May 25, 1909. No. 4977.

Survey Vessels.

Non-Magnetic Survey Yacht Carnegie. Henry J. Gielow. Illustrated description of this vessel, being built for use in ocean surveys to determine the magnetic conditions of deep-water seas. 2500 w. Rudder—May, 1909. No. 4591 C.

Tank Steamers.

Design of a Vessel for Oil Transport (Entwurf eines Petroleum-Transport-Fahrzeuges). G. Zeyss. Describes the design of a tank steamer of 700 tons capacity. Ills. Serial, 1st part. 2800 w. Schiffbau—April 28, 1909. No. 4878 D.

Torpedo Testing.

Torpedo Battery in the Mediterranean. Illustrated detailed description of the French experimental station at Léoube Bay, with related information. 4000 w. Engr, Lond—April 23, 1909. No. 4467 A.

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MECHANICAL ENGINEERING.

AUTOMOBILES.

Brixia-Zust.

An Italian Car of the "Four-Inch" Class. Photographs and description of the 25-H. P. Brixia-Zust. 1500 w. Auto Jour—May 1, 1909. No. 4596 A.

Design.

Unsolved Problems of the Motor Car. Col. H. C. L. Holden. Abstract of "James Forrest" lecture before the Inst. of Civ. Engrs. Deals principally with the problems awaiting solution. 2500 w. Auto Jour—May 1, 1909. Serial, 1st part. No. 4599 A.

The Peculiar Requirements of Peculiar Countries. A symposium of opinions of the conditions under which motor cars must be used. The present article deals with Canada and the Federated Malay States. 1800 w. Autocar—May 1, 1909. Serial, 1st part. No. 4600 A.

The Torpedo Body. Its Evolution and Possibilities. Illustrated description of Capt. Masui's design for a new type of body. 600 w. Autocar—May 8, 1909. No. 4703 A.

Immunity from Side-Slip. Illustrated description of the "Safety" chassis, a practical development of the live front axle. 2000 w. Auto Jour—April 24, 1909. No. 4443 A.

Electric.

See Fire Apparatus, under AUTOMOBILES.

E. N. V.

French Newcomer with Aerial Engine. Illustrated notes of a car to be built in France, which in many details departs from current practice. 2500 w. Automobile—May 6, 1909. No. 4534.

Fire Apparatus.

Electric Automobile Fire Apparatus of the Berlin Fire Department (Der elektromobile Löschzug der Berliner Feuerwehr). Illustrated description. Serial, 1st part. 1800 w. Zeitschr d Mit Motorwagen Ver—April 15, 1909. No. 5054 D.

Fuels.

How to Save the Petrol Tax. Deals with fuel-saving practices and economizing devices. Ills. 3000 w. Auto Jour—May 15, 1909. No. 4940 A.

Hillman-Coatalen.

The 12-15 h. p. Hillman-Coatalen Car. Illustrated description of a car of the 4-cylinder type. 1200 w. Autocar—April 24, 1909. No. 4442 A.

Ignition.

Helpful Hints on Ignition Topics. Morris A. Hall. Explains important parts of the ignition systems and troubles of each. Ills. 2500 w. Automobile—May 20, 1909. Serial, 1st part. No. 4793.

See also Lighting, under AUTOMOBILES.

Lighting.

Electric Light for Motorists. Illustrated description of the Bleriot self-contained automatic installation. 1200 w. Auto Jour—May 8, 1909. No. 4665 A.

An All-British Electric Plant for Car Lighting. Illustrated description of a complete ignition and lighting system, with an ingenious constant voltage (Leitner) dynamo. 2000 w. Auto Jour—May 15, 1909. No. 4941 A.

Fog-Penetrating Head-Lamps. Illustrated description of the "Sylverlyte" electric system of burying a lamp in a lens. 1200 w. Auto Jour—May 1, 1909. No. 4597 A.

The Bleriot Lighting and Charging Dynamo. Illustrates and describes a machine for supplying current to the car lamps and for ignition purposes. 1500 w. Autocar—May 15, 1909. No. 4939 A.

Motor Cooling.

An Experiment in Air-Cooling. Illustrated description of the system of E. H. Morgan, which induces a draft through the cylinder jackets by the action of the exhaust, and increases the radiation in hot places by coating them with a chemical. 1200 w. Auto Jour—May 8, 1909. No. 4666 A.

Motor Governing.

The Governing of Automobile Motors (Zur Regelung von Automobil-Gasmaschinen). R. Lutz. A discussion of devices for speed regulation. Ills. 3300 w. Zeitschr d Ver Deutscher Ing—April 17, 1909. No. 5075 D.

Motor Tests.

A Series of Tests on a White Steam Car. C. H. Benjamin and G. A. Young. A report of tests made to determine h. p. output in terms of engine rating and economy at different speeds and loads. Ills. 3000 w. Am Mach—Vol. 32. No. 19. No. 4635.

Packard.

Packard Cars for 1910. Illustrates and describes the latest type of Packard "Thirty', showing new phaeton body and features of the motor. 2500 w. Automobile—May 20, 1909. No. 4794.

Speed Changing.

Speed Changing in Automobiles (Les Changements de Vitesse des Automobiles). E. Girardault and J. Bethenod. A theoretical discussion of the choice of change-speed gears. Ills. 3200 w. Génie Civil—April 17, 1909. No. 4839 D.

Speed Indicators.

Speed Measuring Devices for Automobiles and Locomotives (Geschwindigkeitsmesser für Motorfahrzeuge und Lokomotiven). Herr Pflug. Discusses their use, requirements, and the various classes. 4500 w. Glaser's Ann—April 15, 1909. No. 5057 D.

A Tip Concerning Speedometer Equipment. Suggests a direct-drive, oil-bath, open-scale arrangement. Ills. 1500 w. Auto Jour—May 1, 1909. No. 4598 A.

Tires.

The Manufacture and Care of Tires (Das Wichtigste über den Kautschuk, die Fabrikation und Pflege der Pneumatiks). Dr. K. Dieterich. Shows the importance of the tire problem and the advantages and defects of rubber as a tire material. 4500 w. Zeitschr d Mit Motorwagen Ver—April 15, 1909. No. 5053 D.

Transmissions.

Transmission of Power from Engine to Road Wheels. L. A. Legros. Abstract of paper before Inst. of Auto. Engrs. Discusses details of transmission from the gear box to the back axle. 2500 w. Automobile—May 13, 1909. No. 4653.

White.

See Motor Tests, under AUTOMOBILES.

COMBUSTION MOTORS.

Gas Engines.

The 100-Horse Power Gas Engine. T. W. Burt. An illustrated discussion of current British practice in suction producers and engines. 6500 w. Cassier's Mag—May, 1909. No. 4402 B.

Reciprocating Gas Engines with Previous Compression and Exhaust-Gas Turbines (Kolbengasmaschine mit Vorkompression und Abgasturbine). Felix Langen. Discusses the possibility of combining a gas engine with a low-pressure gas turbine. 2000 w. Zeitschr f d Gesamte Turbinenwesen—April 30, 1909. No. 4883 D.

See also Coke-Oven Gas, under MINING AND METALLURGY, COAL AND COKE.

Gasoline Engines.

The Testing of Petrol Engines. Jas. L. Miller. Read before the Glasgow Tech. College Sci. Soc. Explains the objects of the tests and some methods used. 2500 w. Mech Wld—May 7, 1909. No. 4663 A.

See also Cams, under MACHINE ELEMENTS AND DESIGN.

Gas Power Plants.

Operation of a Small Producer Gas-Power Plant. C. W. Obert. Plan and description of a notable installation, including a 400-h. p. producer gas plant for the operation of refrigerating and electric machinery. 3500 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4412 F.

See also Rolling Mills, under MINING AND METALLURGY, IRON AND STEEL.

Gas Producers.

Col. J. J. Astor's Vibratory Disintegrator. Illustrated description of an ingenious device which manufactures producer gas from peat. 900 w. Sci Am—May 22, 1909. No. 4902.

The Parsy Horizontal Gas Producer (Gazogène à Combustion horizontale pour Fours à Cornues d' Usines à Gaz, Système Parsy). A. Grebel. Describes the producer and its working. Ills. 3000 w. Génie Civil—April 24, 1909. No. 4841 D.

Gas Turbines.

The Pelterie Explosion Turbine. A brief résumé of a new system patented by the inventor, M. Esnault-Peltrie. 800 w. Auto Jour—April 24, 1909. No. 4444 A.

See also Gas Engines, under COMBUSTION MOTORS.

HEATING AND COOLING.

Central Plants.

Central Heating and Lighting Plant for the United States Military Academy. Henry C. Meyer, Jr. Plan and illustrated description of the plant at West Point to serve a group of buildings. 4500 w. Eng Rec—May 1, 1909. Serial, 1st part. No. 4392.

Central Hot-Water Heating Systems (Fernwarmwasserheizungen). O. Krell. Examines the possibility of installing a system similar to that of the New York Steam Company in Nürnberg, Germany. Ills. 2800 w. Gesundheits-Ing—April 24, 1909. No. 4889 D.

Heating Systems.

A Few Principles for Heating Buildings. R. W. Kings. Considers the main points to be borne in mind by engineers. 6000 w. Con Rec—May 12, 1909. No. 4675.

Hot-Air Heating.

An Unusual Residence Furnace Heating Plant. Describes a trunk main system with arrangements for return air circulation which is effected by open fireplaces. Ills. 3000 w. Met Work—May 8, 1909. No. 4556.

Hot-Water Heating.

See Central Plants, under HEATING AND COOLING.

Plumbing.

Plumbing Plans and Specifications. O. B. Craig. Presents the advantages of proper plans and specifications. Drawings. 2000 w. Met Work—May 8, 1909. No. 4557.

Plumbing in the Lackawanna Railroad Station at Scranton, Pa. Illustrated description of the Durham system of drainage used and unusual features of the water installation. 1800 w. Met Work—May 22, 1909. No. 4914.

Refrigeration.

Artificial Refrigeration. James T.

Ludlow. A non-technical description of the anhydrous ammonia compression system. Ills. 4000 w. Cal Jour of Tech—April, 1909. No. 4760.

A New Compression Refrigerating Machine (Een nieuwe Constructie van Compressie-Koelmachines en eenige toepassingen der kunstmatige koude). J. F. H. Koopman. Refers particularly to the Audiffren machine. Ills. 6000 w. De Ingenieur—April 3, 1909. No. 5080 D.

Steam Heating.

See Shop Heating, under MACHINE WORKS AND FOUNDRIES.

Temperature Regulators.

A New Automatic Temperature Regulator (Ein neuer selbsttätiger Temperaturregler). A. Busau. Illustrated description. 1900 w. Gesundheits-Ing—April 10, 1909. No. 4886 D.

HYDRAULIC MACHINERY.

Centrifugal Pumps.

Centrifugal Pump Efficiency. V. V. Messer. Shows the expense of running an inefficient pump, and discusses details that affect the efficiency. Ills. 2000 w. Min & Sci Pr—May 15, 1909. No. 4792.

Hydrostatics.

Hydraulic Pressure and Transmission of Power. George E. Evans. Prize Essay. The present number gives a brief historical review of the use of water under pressure as a motive power, and a study of the underlying principles. Ills. 4500 w. Plumb & Dec—May 1, 1909. Serial, 1st part. No. 4661 A.

Penstocks.

The Design of Steel Pipes for Hydro-Electric Plants. Richard Muller. Diagrams and discussion of the design of steel penstocks for power plants. 2500 w. Eng Rec—May 1, 1909. No. 4394.

Pumping Plants.

Notes on the Designing of Modern Water Works Pumping Stations. Ernest R. Matthews. With special reference to the new pumping station in course of erection at Bridlington. Ills. 3000 w. Surveyor—April 23, 1909. No. 4452 A.

Pumps.

See same title, under MINING AND METALLURGY, MINING.

Pump Valves.

Valves for High-Speed Pumps. Illustrated description of a new design. 700 w. Engng—May 14, 1909. No. 4962A.

Turbine Plants.

A Suggestion for Improvement in the Use of Fine Screens in Water-Power Plants (Vorschläge für eine Verbesserung der Feinrechen bei Wasserkraftanlagen). Theodor Koehn. A discussion of the best means of protecting turbine machinery against the entrance of foreign matter in the water. Ills. 5000 w. Die Turbine—April 20, 1909. No. 4879 D.

Turbines.

See Hydro-Electric, under ELECTRICAL ENGINEERING, GENERATING STATIONS.

MACHINE ELEMENTS AND DESIGN.

Ball Bearings.

Ball Bearings—Origin, Manufacture, Design and Application. E. Sachs. Address before the Polytechnische Verein. Ills. 1500 w. Automobile—May 13, 1909. No. 4654.

Some Notes on Ball Bearings. Asher Golden. Methods of eliminating friction, materials and various related subjects. Ills. 4000 w. Mach, N Y—May, 1909. No. 4429 C.

Cams.

Laying Out Cams for Brown and Sharpe Screw Machine. F. W. Wright. Diagrams and description. 1500 w. Mech Wld—May 7, 1909. No. 4664 A.

Marine Engine Cams. Albert H. Ziegler. The designing and constructing of cams to obtain accurate cam action is discussed. Diagrams. 2500 w. Rudder—May, 1909. No. 4593 C.

Crank Shafts.

Guests's Law of Combined Stress. C. A. Smith. Sketches the reasoning for a general case, and applies it to a particular example. Diagrams. 3000 w. Engng—April 23, 1909. No. 4459 A.

Flywheels.

Use Cylindrical Flywheels for Safety. A. L. Hodges. Claims that widening rim and shortening radius will obviate explosions without sacrificing convenience, cost or efficiency. 1500 w. Power—May 4, 1909. No. 4489.

Journal Loads.

Journal Loads in Geared Mechanisms. John Egdar. Points out modifications that must be made in the general theory that the gear-tooth pressure is transmitted directly to the journal bearings in inverse proportion to their distance from the gear. Diagrams. 2500 w. Am Mach—Vol. 32. No. 21. No. 5016.

Rivetted Joints.

The Strength of Rivetted Joints (De la Résistance des Pièces rivées). Ch. Fremont. A report of extended researches. Ills. 16800 w. Bul Soc d' Encour—April, 1909. No. 4866 G.

Shafts.

Some Problems in Shaft Design, with a Graphic Method of Solution. Gives a problem and a demonstration of a graphic method for its solution. 1500 w. Prac Engr—April 30, 1909. No. 4605 A.

MACHINE WORKS AND FOUNDRIES.

Blacksmith Shops.

Anvils and Forges. James Cran. Discusses points relating to blacksmith shop equipment. Ills. 2000 w. Mach, N Y—May, 1909. No. 4428 C.

We supply copies of these articles. See page 723.

Boiler Making.

The Manufacture of Sectional Boilers for Central Heating Plants (Fabrikation von gusseisernen Gliederkesseln für Zentralheizungen). Frz. Kerth. Illustrated description of method. Serial, 1st part. 1500 w. Giesserei-Zeit—April 1, 1909. No. 4863 D.

Boring.

Boring Bars and Heads. Lucien L. Haas. Description, with illustrations of twenty designs. 1500 w. Mach, N Y—May, 1909. No. 4425 C.

Brass Founding.

Notes on Brass Melting. Charles T. Bragg. Discusses the causes for variations of composition of an alloy while in the furnace, and the making of alloys of standard composition. 3000 w. Am Brass Found Assn—May 18, 1909. No. 5112 N.

The Manufacture of Red Brass Ingot; Its Uses and Advantages. W. M. Corse. An account of the manufacture of high-grade ingot brass. 2500 w. Am Brass Found Assn—May 18, 1909. No. 5114 N.

The Production of the "Barbedienne" or Dark Brown Finish on Metals. Explains how to produce this finish. 1000 w. Brass Wld—May, 1909. No. 4748.

See also Cost Systems, under INDUSTRIAL ECONOMY.

Castings.

The Practical Value of Chemical Standards for Iron Castings. John Jermain Porter. Discusses the importance of chemical composition. 2000 w. Am Found Assn—May 18, 1909. No. 5125 N.

The Practical Value of Chemical Standards for Iron Castings. John J. Porter. Read at meeting of Am. Found. Assn. Suggests investigations that would be of benefit to the foundry industry. 2200 w. Ir Trd Rev—May 20, 1909. No. 4796.

Open-Hearth Methods for Steel Castings. W. M. Carr. With remarks on the small open-hearth furnace. Ills. 2200 w. Am Found Assn—May 18, 1909. No. 5123 N.

Casting Internal Screw Threads. Walter J. May. Suggestions for such work. Ills. 600 w. Prac Engr—May 14, 1909. No. 4949 A.

Molding and Casting 90-Ton Frames. Illustrated description of method of making large engine beds for gas engines. 2200 w. Foundry—May, 1909. No. 4496.

Casting Steam Engine Cylinders. N. W. Shed. Methods of moulding and casting various types of cylinders are illustrated and described. 2200 w. Foundry—May, 1909. No. 4499.

See also Converters, under MACHINE WORKS AND FOUNDRIES.

Cleaning.

Researches on the Cleaning of Metals (Neuere Untersuchungen über das Beizen). Julius Grünwald. Results of extended investigations on metal-cleaning baths of various compositions. Ills. 3800 w. Stahl u Eisen—April 14, 1909. No. 4855 D.

Converters.

The Side-Blow Converter for Steel Castings, and Its Operation. J. S. Whitehouse. Reviews the difficulties of this process, explaining the causes of failures. 1200 w. Am Found Assn—May 18, 1909. No. 5116 N.

Cores.

Cores and Core Making. F. R. Cheney. Discusses core binders and making cores. 1500 w. Am Found Assn—May 18, 1909. No. 5126 N.

Brass Valve Core Shop Practice. Illustrated description of highly specialized moulding methods. 2000 w. Foundry—May, 1909. No. 4501.

Cupola Practice.

Modern Cupola Practice. John C. Knoeppel. Suggestions for the management of the cupola. 2500 w. Am Found Assn—May 18, 1909. No. 5117 N.

Continuous Melting. Richard H. Probert. Explains the advantages of the continuous melting process. 2000 w. Am Found Assn—May 18, 1909. No. 5121 N.

Continuous Melting in the Foundry Cupola. Richard H. Probert. Read before the Am. Found. Assn. Describes cupola details and methods used. 2000 w. Ir Age—May 20, 1909. No. 4766.

Drilling.

Countersunk Drilling and Riveting. T. Leonard Bott. Illustrates designs of gages and tools which seem to have overcome the difficulties of this class of work. 1200 w. Mech Wld—May 14, 1909. No. 4952 A.

Forging Hammers.

A New Forging-Hammer and Oil Furnace. Illustrated description of designs by E. S. Brett. 1500 w. Engng—May 14, 1909. No. 4960 A.

Foundries.

Modern Malleable Iron Foundry Practice (Moderne Tempergiesserei). E. Schoemann. Describes a model foundry in Delstern, Germany. Ills. 2300 w. Stahl u Eisen—April 21, 1909. No. 4858 D.

Foundry Accidents.

Report of the Committee on Prevention of Accidents in Foundries. A discussion of injuries and their remedies. Ills. 3000 w. Am Found Assn—May 18, 1909. No. 5115 N.

Foundry Materials.

Standardizing Foundry Facings. H. F. Frohman. Suggestions for the more common varieties of foundry facings in use. 1200 w. Am Found Assn—May 18, 1909. No. 5119 N.

The Use of Steel Scrap in the Cupoal. C. R. McGahey. Hints of use to the foundry man. 1200 w. Am Found Assn—May 18, 1909. No. 5120 N.

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Foundry Practice.

Poetry and Prose in Foundry Work (Poesie und Prosa aus der Giesserei). J. Leber. Describes principally the methods used in producing large castings. Ills. 2800 w. Stahl u Eisen—April 28, 1909. No. 4860 D.

See also Pyrometry, under MEASUREMENT.

Furnaces.

The Use of Pulverized Coal for Foundry Purposes. Richard K. Meade. Presents the advantages of this fuel. 2000 w. Am Found Assn—May 18, 1909. No. 5122 N.

A New Electrical Hardening Furnace. Abstract of a paper by E. Sabersky and E. Adler, read before the Faraday Soc. Illustrated description of a new furnace heated by electricity and intended mainly for hardening steels. 2500 w. Mech Engr—May 14, 1909. No. 4951 A.

Electric Hardening Furnaces. Abstract of paper by Messrs. E. Sabersky and E. Adler, before the Faraday Soc., and of the discussion. Deals with details of the hardening furnace with electrically heated salt bath. 2500 w. Elec Chem & Met Ind—May, 1909. No. 4507 C.

Notes on Air Furnace Construction for Malleable Castings. W. H. Kane. Gives recommendations relating to this furnace. Ills. 1000 w. Am Found Assn—May 18, 1909. No. 5124 N.

New Hardening Furnaces (Neues über Härteöfen). H. Haedicke. Brief descriptions of furnaces of various types. Ills. Serial, 1st part. 2000 w. Stahl u Eisen—April 28, 1909. No. 4861 D.

See also Castings, and Forging Hammers, under MACHINE WORKS AND FOUNDRIES.

Grinding Machines.

The Brown & Sharpe No. 12 Plain Grinder. Illustrated description of a new size having a number of improvements. 1200 w. Ir Age—May 27, 1909. No. 5009.

Lathes.

Large Turbine Rotor Lathe. Illustrated description of a lathe capable of swinging rotors with their blades up to 17 ft. diameter, and which will admit work up to 55 ft. in length. 600 w. Engr, Lond—May 14, 1909. No. 4969 A.

Circular Dividing Attachment for the Bench Lathe. Walter Gribben. Illustrated description. 2500 w. Am Mach—Vol. 32. No. 19. No. 4634.

Molding.

The Use of Artificial Graphite in Making Permanent Molds. Illustrates and describes method of making the molds, and castings produced. 1500 w. Brass Wld—May, 1909. No. 4747.

Molding Eighty-Ton Engine Frames. Illustrates and describes an example of pit molding. 1200 w. Foundry—May, 1909. No. 4590.

Permanent Molds for Iron Castings. Edgar A. Custer. An illustrated summary of results of recent practice. 5500 w. Ir Age—May 20, 1909. No. 4767.

Making a Large Combination Mold. Jabez Nall. Illustrates and describes an example of core molding combined with green sand and skin dried work. 2500 w. Foundry—May, 1909. No. 4498.

See also Castings, Cores, and Foundry Materials, under MACHINE WORKS AND FOUNDRIES.

Molding Machines.

Machine Molding vs. Hand Molding. George Muntz. A discussion of molding machines, the principles that should be observed, etc. 2500 w. Am Found Assn—May 18, 1909. No. 5118 N.

See also Patterns, under MACHINE WORKS AND FOUNDRIES.

Patterns.

Patterns for Molding Machines. S. Jones Parsons. Gives examples of work that can be done on a plain molding machine. Ills. 600 w. Mech Wld—May 7, 1909. Serial, 1st part. No. 4662 A.

Pattern Shops.

The Modern Pattern Shop Layout. A. N. Spencer. Detailed discussion of the equipment and arrangement. 3500 w. Foundry—May, 1909. No. 4497.

Presses.

The Operation of Friction Presses (Der Arbeitsgang von Friktionspressen). Oskar Kron. Describes the construction and operation of various types. Ills. Serial, 1st part. 2800 w. Zeitschr f Werkzeug—April 5, 1909. No. 5059 D.

Press Tools.

Cutting and Piercing Punch and Die. Henry Percival. Drawings and description of a punch and die for cutting and piercing mild steel blanks. 1500 w. Am Mach—Vol. 32. No. 20. No. 4773.

Rivetting.

See Drilling, under MACHINE WORKS AND FOUNDRIES.

Shapers.

Comparative Tests of Two Shapers. Henry P. Noble. Tests to determine the relative wear, accuracy of work, deflection, and power consumed. Ills. 2000 w. Am Mach—Vol. 32. No. 18. No. 4517.

Shop Appliances.

Proper Designing of Milling and Drilling Fixtures and Jigs. R. B. Little. Gives a catechism of things to be considered before designing. 1500 w. Mach, N Y—May, 1909. No. 4427 C.

Special Automobile Factory Tools and Devices. Ethan Viall. Illustrates tools used in a Buffalo shop. 2000 w. Mach, N Y—May, 1909. No. 4426 C.

Shop Heating.

Heating Plant of the German Auer Light Company, Berlin (Die Heizungsan-

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lage im Fabrikgebäude der deutschen Gasglühlicht-Aktiengesellschaft, Berlin). Karl Brabée. A discussion of high-pressure, live-steam heating. Ills. 6000 w. Gesundheits-Ing—April 3, 1909. No. 4884 D.

Shop Hygiene.

The Separation of Dust from Air (Die Trennung von Staub und Luft in Absauganlagen). Ewald Mees. Describes various apparatus for separating dust from aid in industrial plants. Ills. 2700 w. Zeitschr d Ver Deutscher Ing—April 17, 1909. No. 5073 D.

Shop Lighting.

See Incandescent Lamps, under ELECTRICAL ENGINEERING, LIGHTING.

Shop Practice.

Interesting Methods in the Thomas Shop. Illustrates and describes methods of setting and boring cylinders, fixtures for crank cases, cam shafts, Gisholt lathes and grinders, and a device for testing springs. 2000 w. Am Mach—Vol. 32. No. 20. No. 4772.

See also Gages, under MEASUREMENT.

Tempering.

High-Speed Steel: A Suggested Theory. Abstract of a lecture by H. C. H. Carpenter on a theory of hardening high-speed tool steel. 2500 w. Ir & Coal Trds Rev—May 7, 1909. No. 4733 A.

The Manufacture of High-Speed Steel. O. M. Becker. An illustrated discussion of the barium-chloride hardening process. 3000 w. Cassier's Mag—May, 1909. No. 4401 B.

Welding.

Electric Welding. V. D. Green. Abstract of a paper read before the Birmingham & District Elec. Club. Briefly outlines the systems of electric welding in use, particularly describing the system invented by Elihu Thomson. 1800 w. Elect'n, Lond. May 7, 1909. No. 4718 A.

Autogenous Welding by the Oxy-Acetylene Process. I. F. Willis. Brief explanation of this process and its applications. 1800 w. Pro St Louis Ry Club—April 9, 1909. No. 4544.

Aluminum Welding. M. U. Schoop. Deals with the applications of autogenous welding and with types of burners especially suitable for welding aluminum. Ills. 1700 w. Elec-Chem & Met Ind. May, 1909. No. 4505 C.

Thermit Welding. Douglas Waterman. A report of its successful application in the repair of cracked and broken buckets, gear-wheels, and other heavy castings. Ills. 1200 w. Min & Sci Pr—May 22, 1909. No. 5011.

Wood-Working Machines.

A New Mechanical Woodworker. Illustrated detailed description of the machine and its operation. 6500 w. Am Mach—Vol. 32. No. 19. No. 4633.

MATERIALS OF CONSTRUCTION.

Alloys.

The Plastic-Bronze Patent Situation. G. H. Clamer. An account of the suit against the Brady Brass Co., and Judge Archbold's decision; the appeal and Judge Grays decision. 2500 w. Brass Wld—May, 1909. No. 4749.

Alloy Steels.

Alloy Steels for Motor-Car Construction. John A. Matthews. Considers certain economic features in connection with the manufacture, purchase, use, and treatment of alloy steels. 6500 w. Jour Fr Inst—May, 1909. No. 4763 D.

Manganese Steel. W. S. Potter. Considers its physical properties, heat treatment, rolling, testing, etc. General discussion. Ills. 9500 w. Jour W Soc of Engrs—April, 1909. No. 4788 D.

Nickel Steel Spoiled by Forging at Too High a Temperature (Durch zu hohe Schmiedehitze verdorbenes Nickelflusseisen). E. Heyn and O. Bauer. Results of investigations of its properties. Ills. 1500 w. Stahl u Eisen—April 28, 1909. No. 4862 D.

Metallography.

Polishing Metals for Examination With the Microscope. Albert Kingsbury. Describes the method finally adopted by the author. 1500 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4409 F.

The Metallography of Tempered Steels (Remarques au Sujet des Mémoires de M. Kourbatoff et de M. Maurer sur la Métallographie des Aciers trempés). Carl Benedicks. A discussion of papers by MM. Kourbatoff and Maurer. 3500 w. Rev de Métal—April, 1909. No. 4821 E + F.

Researches on the Alloys of Iron and Sulphur (Recherches sur les Alliages du Fer avec le Soufre). M. Ziegler. An exhaustive metallographic and chemical study. Ills. 13500 w. Rev de Mécan—April, 1909. No. 4820 E + F.

Steel.

The Present Value of Electrical Structural Steel. Henry D. Hibbard. Read before the Am. Elec.-Chem. Soc. Compares electric steel with steel made by the Bessemer and open hearth processes. 2000 w. Ir Trd Rev—May 13, 1909. No. 4643.

The Influence of Heat Treatment on the Linear Deformations of Steels (Influence du Traitement thermique sur les Déformations linéaires des Aciers). M. Demozay. Results of extended tests on steels of various compositions. Ills. 10500 w. Rev de Métal—April, 1909. No. 4818 E + F.

Tool Steels.

A Tool-Steel Testing Machine and Results. Edward G. Herbert. Illustration, with description of the principle and construction of the machine and report of results. 7500 w. Am Mach—Vol 32. No. 20. No. 4774.

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MEASUREMENT.

Dynamometers.

A New Transmission Dynamometer. William H. Kenerson. Illustrated description of the design and construction of the instrument and its method of application and use. 1500 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4410 F.

Power Measurements (La Mesure des Puissances). J. Izart. The first part discusses methods of measuring power transmitted by belts, ropes, gearing, etc. Ills. Serial, 1st part. 3500 w. Elecn—April 24, 1909. No. 4826 D.

Gages.

Thomas Gages and Gaging Methods. Illustrates and describes devices used for accurate work on the Thomas car. 2000 w. Am Mach—Vol. 32. No. 21. No. 5013.

Impact.

Some Experiments on Impact. J. E. Sears, Jun. Explains the theory and methods used, and describes experiments to determine the required relationships for stresses. 3000 w. Engng—April 30, 1909. Serial. 1st part. No. 4622 A.

Pyrometry.

Temperature Determination and Control for High-Speed Steel Treatment. O. M. Becker. This second article of a series discusses the principles and uses of pyrometers of the optical and radiation types, and recording apparatus. Ills. 2500 w. Engineering Magazine—June, 1909. No. 4986 B.

The Use and Application of Pyrometers in Foundry Work. Charles E. Foster. Considers types and their use. Ills. 3000 w. Foundry—May, 1909. No. 4502.

The Féry Spiral Pyrometer. Illustrated description. 1200 w. Engng—May 14, 1909. No. 4963 A.

Testing Machines.

See Tool Steels, under MATERIALS OF CONSTRUCTION.

POWER AND TRANSMISSION.

Air Compressors.

Hoerbiger-Rogler Compressors and Blowers. Illustrated description of an electrically-driven air-compressor, and a blowing engine equipped with these valves. 800 w. Engng—May 7, 1909. No. 4726 A.

Electrically Driven Air Compressors (Elektrisch angetriebene Kompressoren). J. Havlicek. A theoretical discussion of their operation, governing, etc. Ills. 5000 w. Zeitschr d Ver Deutscher Ing—April 10, 1909. No. 5071 D.

Belt Driving.

Belt Driving and Gehrckens' Theory (Das Riemengetriebe und die Gehrckenssche Theorie). Ludwig Benjamin. A theoretical consideration of belt driving problems. Ills. 7500 w. Zeitschr d Ver Deutscher Ing—April 24, 1909. No. 5078 D.

Belting.

Leather Belting. Information helpful in the selection of good belting. Ills. 1500 w. Am Engr & R R Jour—May, 1909. No. 4423 C.

German Steel Belts for Transmitting Power. H. Prime Kieffer. Illustrated description of the Eloesser steel belt, especially the method of locking the ends of the belt. 1400 w. Ir Age—May 20, 1909. No. 4768.

Costs.

See same title, under ELECTRICAL ENGINEERING, GENERATING STATIONS.

Electric Driving.

Mechanical Considerations in the Application of Electric Motors to Industrial Machinery. C. B. Mills. Discusses belt, rope, and chain connections. 2000 w. Elec Jour—May, 1909. No. 4546.

Discussion on "The Industrial Application of the Electric Motor," New York, March 12, 1909. Discussion on B. R. Shover's paper. 5800 w. Pro Am Inst of Elec Engrs—May, 1909. No. 4996 F.

Electric Motors in Steel Mills. Comments of electrical engineers on the unusual problems worked out at Gary, Ind. 4000 w. Ir Age—May 20, 1909. No. 4765.

The Electrification of Steam-Driven Non-Reversing Rolling Mills. W. F. Mylan. Read before the Leeds Sec. of the Inst. of Elec. Engrs. Considers important features to bear in mind, giving particulars of actual installations. 6000 w. Elec Engr, Lond—May 7, 1909. No. 4714 A.

Electric Drive for Rolling Mills (Ueber elektrische Walzenstrassenantriebe). V. Graubner. A discussion of its economy. Ills. Serial, 1st part. 3200 w. Elektrotech u Maschinenbau—April 25, 1909. No. 5069 D.

Electric Driving in the Textile Industries (La Commande électrique des Métiers en Filature). D. de Prat. Reviews the advatanges of the electric drive and the extent of its use in the textile industries. Ills. 2500 w. Génie Civil—April 3, 1909. No. 4835 D.

See also A. C. Motors, under ELECTRICAL ENGINEERING, DYNAMOS AND MOTORS.

Gearing.

See Journal Loads, under MACHINE ELEMENTS AND DESIGN.

Mechanical Plants.

Mechanical Plant of the Keyser Building, Baltimore. Plan and description of unusual features to meet conditions. 2000 w. Eng Rec—May 22, 1909. No. 4926.

Power Plants.

Mechanical Equipment of the Plaza Hotel. Warren O. Rogers. Illustrated description of the power plant of New York's finest hotel. 3000 w. Power—May 18, 1909. No. 4738.

Power Plant of the Cleveland Arcade. H. W. Woodward. Illustrates and de-

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scribes the method of solving a difficult problem in power plant design. 3500 w. Ind Engng—May, 1909. No. 4785 C.

The Power Plant of the A. E. G. Turbine Works at Berlin (Das Kraftwerk der A. E. G-Turbinenfabrik in Berlin). O. Lasche. Illustrated description of a plant in which the prime movers are turbines undergoing tests before delivery to purchasers. Serial, 1st part. 2800 w. Zeitschr d Ver Deutscher Ing—April 24, 1909. No. 5077 D.

Solar Energy.

Power from the Sun's Heat. Illustrates and describes what has been accomplished by Frank Shunan at Philadelphia. 3500 w. Eng News—May 13, 1909. No. 4644.

Experiments in the Development of Power from the Sun's Heat. H. E. Willsie. An outline of work in the effort to make sun power commercially possible. Also editorial. Ills. 6500 w. Eng News—May 13, 1909. No. 4645.

Turbo-Compressors.

Turbine Blowers (Ueber Turbogebläse.) H. Naville. Reviews their development, theory, construction and operation, and describes installations. Ills. 3100 w. Stahl u Eisen—April 7, 1909. No. 4801 D.

Turbine Blowers (Ueber Turbogebläse). A. Dahme. A review of their theory and development. Ills. 1400 w. Zeitschr f d Gesamte Turbinenwesen—April 20, 1909. No. 4800 D.

High-Pressure Turbo-Compressors and the Utilization of Exhaust Steam (Turbo-Compresseurs à haute Pression et Utilisation des Vapeurs d'Echappement). A. Rateau. Abstracted from the *Revue Universelle des Mines*. Ills. 6500 w. All Indus—April, 1909. No. 4827 D.

Speed Regulation of Electrically Driven Turbo-Blowers (Die Regelung der Umdrehungszahl elektrisch angetriebener Turbogebläse). Herr Scherbius. A description of a special Brown, Boveri & Co. three-phase motor. 1800 w. Stahl u Eisen—April 14, 1909. No. 4856 D.

STEAM ENGINEERING.

Boiler Management.

Efficiencies of Combustion Processes Compared. Theodore J. Vollkommer. Gives facts that assist in comparing the merits of the different processes, and the general conclusions reached. 3500 w. Ir Age—May 6, 1909. No. 4512.

Increasing the CO_2 Content of Flue Gases. A. J. Boardman. Reports an investigation of combustion conditions under ten boilers using bituminous slack. 1500 w. Power—May 18, 1909. No. 4739.

Boiler Waters.

The Technical Examination of Boiler Waters. A paper by W. A. Hargreaves read before the Australasian Assn. for the Adv. of Science, with letters discussing statements made. 3000 w. Eng News—May 20, 1909. No. 4780.

Condensers.

Evaporative Condenser at Southend. Illustrated description of a very large plant embodying the latest improvements. 1500 w. Engr, Lond—April 23, 1909. No. 4468 A.

The Leblanc Ejector Condenser. Illustrated description of the rotary air-pump and condenser invented by Maurice Leblanc. 700 w. Engng—May 7, 1909. No. 4725 A.

The Design of Suction and Delivery Pipes for Condensing Plants. Discusses points in the design. 3500 w. Elec Rev, Lond—April 23, 1909. No. 4448 A.

Condensing Plants.

Pumps and Turbines for Condensing Plants. Illustrated description of plants where the water used for condensing is made to perform useful work. 700 w. Engr, Lond—May 14, 1909. No. 4971 A.

Economizers.

A Suggestion for Overloaded Boiler Plants. Carl S. Dow. An illustrated explanation of the value of an economizer. 2500 w. Engineering Magazine—June, 1909. No. 4989 B.

Engine Governing.

Recent Shaft Governors (Neuere Flachregler mit regelbarer Umlaufszahl). R. Proell. Illustrated description and discussion of the Proell governor. 2700 w. Zeitschr d Ver Deutscher Ing—April 10, 1909. No. 5072 D.

Engine Pressures.

The Influence of Steam Pressure, Speed of Rotation, and Number of Expansions Upon the Mean Effective Pressure and Steam Consumption of Steam Engines. R. Royds. Discusses the best methods of experimenting in this field. Diagrams. 4500 w. Inst of Engrs & Shipbldrs in Scotland—April 27, 1909. No. 4609 N.

Engines.

Lanz Portable Engines with Lentz Valves (Industrie-Locomobilen mit Ventilsteurung "System Lentz" der Firma Heinrich Lanz in Mannheim). Fr. Freytag. Illustrated description. Serial. 1st part. 1300 w. Elektrotech Rundschau—April 24, 1909. No. 5060 D.

Flue-Gas Analysis.

The "Krell" Continuous CO_2 Recorder. Diagram and description with explanation of the method of operation. 1500 w. Elec Engr, Lond—May 14, 1909. No. 4942 A.

Fuel Oil.

Calorific Value of California Fuel Oil. R. W. Fenn. A tabulated comparison of crude oils of different densities, with related information. 2000 w. Eng News—May 13, 1909. No. 4647.

Fuels.

The Economy of Fuel. William Kent. Read at the Pan-American Congress, Dec., 1908. A discussion of fuel wastes, and

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methods of economically using coal. 5000 w. Ind Engng—May, 1909. No. 4784 C.

I. Results of Purchasing Coal Under Government Specifications. John Shober Burrows. II. Burning the Small Sizes of Anthracite for Heat and Power Purposes. Dwight T. Randall. Gives the general plan and results. 9800 w. U S Geol Surv —Bul. 378. No. 4526 N.

See also Briquetting, under MINING AND METALLURGY, COAL AND COKE.

Fuel Testing.

Heat Value of Coal from Dulong's Formula, Based on Ultimate Analysis. N. A. Carle. Aims to cover the determination of the probable total heat of combustion from the chemical analysis, and gives a chart showing graphically the heat value as calculated by this formula. 800 w. Power—May 11, 1909. No. 4587.

Smoke Prevention.

Smoke Prevention or Smoke Consumption. Harold V. Coes. This first of two articles discussing smoke prevention in stationary steam-boiler practice, deals with the causes of smoke and the methods and devices which tend to make possible smokeless combustion in hand-fired furnaces. 3500 w. Engineering Magazine—June, 1909. No. 4988 B.

Steam Properties.

Some Properties of Seam. Prof. R. C. H. Heck. Gives experimental results as to the relation between pressure and temperature of saturated steam, and the specific heat of water. 3000 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4413 F.

The Specific Volume of Saturated Steam. Prof. C. H. Peabody. Gives a comparison of experimental and computed values with explanations. 2200 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4407 F.

Steam Separators.

Some Live Steam Separator Tests. G. F. Gebhardt. Describes tests made at Armour Inst. of Technology, and states the conclusions drawn. 1000 w. Power—May 11, 1909. No. 4586.

Stoking.

Methods of Firing Cheap Grades of Bituminous Coal. William Kavanagh. Describes briefly the six ways in which soft coal can be fired. 1000 w. Elec Wld—May 6, 1909. No. 5036.

Superheating.

A New Principle in Superheaters. Illustrated description of the "Unit Superheater," which provides a system of expanded flows. 1200 w. Ir & Coal Trds Rev—April 23, 1909. No. 4475 A.

Superheated Steam (La Vapeur d'Eau surchauffée). L. Marchis. A review of the properties of superheated steam and of the design and operation of superheating apparatus. Ills. Serial. 1st part. 4500 w. Tech Mod—April, 1909. No. 4830 D.

Superheating in Marine Practice (L'Application de la Surchauffe aux Moteurs de Navires.) O. H. Wildt. Discusses the application and economy of superheated steam in marine engines and turbines, superheaters, etc. Ills. 4000 w. Génie Civil —April 17, 1909. No. 4840 D.

Turbine Plants.

The Exhaust Steam Turbo-Generator Plant at the Zollverein Mine (Die Abdampf-Turbogeneratoranlage auf Zeche Zollverein., Schacht 4/5). Describes a 900-kw. installation and discusses its economy. Ills. 2000 w. Zeitschr f d Gesamte Turbinenwesen—April 10, 1909. No. 4881 D.

Turbines.

Small Steam Turbines. George A. Orrok. Treats of the smaller sizes from the standpoint of the designing and operating engineer, describing the commercial machines and giving facts concerning their operation. 2000 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4411 F.

Small Steam Turbines (Les petites Turbines à Vapeur). Jules Vinsonneau. Refers particularly to the uses of, and results obtained with, the Brien turbine. Ills. 3500 w. Rev Indus—April 10, 1909. No. 4828 D.

The Bergmann Steam Turbine (Die Bergmann-Dampfturbine). Philipp Reuter. Illustrated detailed description. Serial. 1st part. 1800 w. Die Turbine—April 20, 1909. No. 4880 D.

Turbine Tests.

Steam Consumption Tests of a 500-kw. Turbo-Generator Set. A. C. Scott. A report of tests and results. Ills. 1200 w. Elec Wld—May 6, 1909. No. 5033.

See also Power Plants, under POWER AND TRANSMISSION.

Valve Gears.

Reversing Valve Gears in General Use. Simpson Rice. An illustrated review of the types which have stood the test of continuous or intermittent operation, and a study of their characteristics. 4500 w. Power—May 11, 1909. No. 4584.

TRANSPORTING AND CONVEYING.

Automatic Feeders.

Automatic Feeders for Handling Material in Bulk. C. Kemble Baldwin. Illustrated description of the various types now in use. 1600 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4408 F.

Cableways.

The Electric Aerial Mono-Rail Up the Wetterhorn. Illustrated detailed description of an aerial railway in Switzerland, operated on the "compensating' system, and taking passengers to a height of some 5250 feet above sea level. 1500 w. Sci Am—May 8, 1909. No. 4540.

Conveyors.

A Unique Belt Conveyor. E. C. Soper. Description of a belt conveyor a quarter of a mile long, requiring more power to

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operate empty than loaded. Line drawings and illustrations. 1000 w. Jour Am Soc of Mech Engrs—May, 1909. No. 4415 F.

Cranes.

Notes on Shafting for Cranes. E. G. Fiegehen. An illustrated discussion of details in the design of a shaft for a given service. 2000 w. Mech Wld—April 30, 1909. Serial. 1st part. No. 4608 A.

Tower Cranes and Transporters. Illustrated description of electrically-driven cranes for a large shipbuilding firm in Holland. 700 w. Engr, Lond—April 23, 1909. No. 4471 A.

Elevators.

The Traction Elevators in the Singer Building, New York. Illustrated detailed description of the operating principle of the high-rise machines for this building which exceeds 600 ft. in height. 4000 w. Eng Rec—May 1, 1909. No. 4395.

Power Requirements of Hydraulic and Electric Elevators (Arbeitsverbrauch eines hydraulisch und eines elektrisch betriebenen Personenaufzuges.) Herr Mühlmann. The results of comparative tests are given. Ills. Serial. 1st part. 2500 w. Elek Kraft u Bahnen—March 4, 1909. No. 4804 D.

Ore Handling.

See Ore Bins, under MINING AND METALLURGY, MINING.

MISCELLANY.

Aeronautics.

Aviation (Aviation). Gérard Lavergne. The first article gives a review of early attempts to build flying machines. Serial. 1st part. 1500 w. Rev Indus—April 17, 1909. No. 4829 D.

Aeroplane Problems. Herbert Chatley. The present number discusses difficult problems in construction. 3000 w. Sci Am Sup—May 22, 1909. Serial. 1st part. No. 4905.

Gyroscopic Balancing of Aeroplanes. Lucien Fournier. Suggested methods of maintaining equilibrium are illustrated and described. 1400 w. Sci Am Sup—May 15, 1909. No. 4640.

Recent Successful French Monoplanes. Illustrated descriptions of the "Antoinette V, the "No. XI" Bleriot, and the small monoplane of Santos Dumont. 1000 w. Sci Am—May 8, 1909. No. 4539.

Electricity and Aeronautics (La Electricidad y la Aeronáutica). Eduardo Mier. A discussion of the possibility of applying storage batteries and electric motors to the propulsion of air-ships. Serial. 1st part. 2200 w. Energia Elec—April 10, 1909. No. 4852 D.

Agricultural Machinery.

The Repair of Farm Equipment. W. R. Beattie. Illustrates and describes useful tools for the farmer. 6000 w. Sci Am Sup—May 29, 1909. Serial. 1st part. No. 5027.

Guns.

Field Guns for Destroying Dirigibles. Illustrates and describes recent German artillery and shells specially designed for bringing down military airships. 2500 w. Sci Am Sup—May 29, 1909. No. 5028.

The Design of Weapons for Attacking Airships. Considers the requirements of such weapons, principally discussing attacks on dirigible balloons. 2500 w. Engr, Lond—May 14, 1909. No. 4970 A.

English Practice.

Recent Developments in Engineering Practice in England. J. F. B. Vandeleur. Read before the Engrs' Club, Toronto. A review of recent developments in civil, mechanical, and electrical engineering. 3500 w. Can Engr—April 30, 1909. No. 4379.

Minting Machinery.

The Manufacture of United States Money. Illustrates and describes methods and appliances used in the Philadelphia mint. 3000 w. Am Mach—Vol. 32. No. 21. No. 5014.

Scientific Follies.

Famous Follies of Science. John Hays Hammond, Jr. Discusses the efforts at circle squaring, schemes for perpetual motion, etc. 3000 w. Yale Sci M—May, 1909. Serial. 1st part. No. 4751 C.

MINING AND METALLURGY.

COAL AND COKE.

Accidents.

First-Aid Movement in the Anthracite Region of Pennsylvania. H. H. Stoek. Illustrated description of the efficient first aid systems installed and the course of instruction given. 3000 w. Engineering Magazine—June, 1909. No. 4983 B.

The Use of Oxygen in Mining Accidents. Dr. James Robertson. Shows the value of oxygen in pit rescues. 1700 w. Col Guard—April 30, 1909. No. 4614 A.

Analysis.

The Analysis of Coal. Lionel S. Marks. An explanation of proximate and ultimate analyses of coal, and of the relation between them. 2500 w. Harvard Jour of Engng—April, 1909. No. 4930 D.

Australia.

Cooktown Coalfield. Lionel C. Ball. Sketch map with description of the topography and geology of the district. 5500 w. Queens Gov Min Jour—April, 1909. No. 4746 B.

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Briquetting.

Coal Briquetting. Carl Scholz. An illustrated article presenting the advantages of briquetting, and discussing methods, cost and related matters. Discussion. 6000 w. Jour W Soc of Engrs—April, 1909. No. 4786 D.

Canada.

See same title, under MISCELLANY.

Coal Cutting.

A Comparison of Coal Cutting Machines. Sydney F. Walker. Showing economy of machine mining and discussing compressed air as compared with electric power. 6000 w. Eng & Min Jour—May 22, 1909. No. 4921.

Coke-Oven Gas.

The Direct Utilization of Coke-Oven Gas in Combustion Motors (Note sur l'Utilisation directe du Gaz de Four à Coke dans les Moteurs à Explosion). M. E. Cuvelette. An exhaustive discussion of the whole subject. 18000 w. Mem Soc Ing Civils de France—Feb., 1909. No. 4807 G.

Coking Plants.

Donahoe Coke Co. C. R. King. Describes the works and mine and methods of operating. Ills. 5500 w. Mines & Min—May, 1909. No. 4478 C.

Coking Properties.

A Study of the Coking Properties of Coals (Etude sur les Charbons et leur Pouvoir cokéfiant). O. Boudouard. An important investigation of the influence of composition, structure, etc. 6500 w. Rev de Mécan—April, 1909. No. 4819 E + F.

Electric Power.

Electricity at a Colliery. Illustrates and describes a plant recently installed at Shamrock Colliery. 1800 w. Engr, Lond—May 14, 1909. No. 4972 A.

Explosions.

Overcoming Coal-Mine Disasters. Guy Elliott Mitchell. Describes the work of the U. S. government in explosion investigations and life-saving in the mines. Ills. 3500 w. Am Rev of Revs—May, 1909. No. 4525 C.

Means for the Prevention of Gas and Dust Explosions (Mittel zur Verhütung von Schlagwetter- und Kohlenstaubexplosionen). Report of tests by the Austrian Committee for the Investigation of mine-gas explosion problems. Ills. Serial. 1st part. 6000 w. Oest Zeitschr f Berg u Hüttenwesen—April 3, 1909. No. 4864 D.

Testing Station of the Central Committee of French Colliery Owners at Liévin (La Station d'Essais du Comité central des Houillères de France à Liévin). Illustrated description of a station built for the purpose of investigating dust explosions. Ills. 7500 w. Génie Civil—April 10, 1909. No. 4837 D.

Formation.

The Origin of Anthracite Coal. Editorial review of theories advanced, and general agreement reached, with a reference to the recent investigations of A. Strahan and W. Pollard of the coals of South Wales. 1500 w. Engng—April 23, 1909. No. 4464 A.

Petroleums and Coals. Eugene Coste. A comparison of their nature, mode of occurrence and origin, aiming to demonstrate that there are really two series of natural compounds of carbon. 5500 w. Can Min Jour—May 15, 1909. Serial. 1st part. No. 4770.

Illinois.

Conditions of the Coal Mining Industry of Illinois. David Ross. A critical review. 1800 w. Min Wld—May 22, 1909. No. 4937.

India.

Longwall Working at the Seeterampore Coal Company's Collieries, Nursamooda, India. Willis Howarth. Explains the physical conditions at Nursamooda, the human conditions, and the mechanical conditions. 2500 w. Ir & Coal Trds Rev—April 30, 1909. No. 4632 A.

Lignite.

Decrease in Weight of Lignite in Transit. Arthur C. Scott. Gives results of experiments with Texas lignite to determine changes in weight and heat value due to temperature and humidity conditions. 2500 w. Power—May 11, 1909. No. 4588.

Mine Dust.

The Coal-Dust Problem. John Verner. Address before the Fuel Conference, at Urbana, Ill. Discusses the mechanical influence of air currents in furnishing conditions favorable to a dust explosion. 5000 w. Mines & Min—May, 1909. No. 4480 C.

Mining.

Avoidable Losses in Mining. H. Morton Middleton. A review of the general causes of the loss of time. 2200 w. Col Guard—May 7, 1909. No. 4723 A.

Geological Relations and Working of Thin Lignite Seams at Müncheberg, Germany (Ablagerungsverhältnisse und Abbau der geringmächtigen Braunkohlenflöze bei Müncheberg). Dr. Tornow. A brief description of the deposits and mining methods. Ills. 3800 w. Glückauf—April 24, 1909. No. 4873 D.

The Nine Hours Day in Austria. Translation of a report by a Commission appointed by the Belgian Government, in regard to the effect on production, earnings, etc. 2500 w. Col Guard—April 23, 1909. No. 4457 A.

See also Eight-Hour Day, under INDUSTRIAL ECONOMY.

Mining Costs.

An Investigation of the Cost of Mining Coal. J. R. Finlay. Gives an analysis of operating costs. 4000 w. Eng & Min Jour—May 8, 1909. No 4568.

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Mining Plants.

Power Plant of a Modern Coal Mine in Alabama. Illustrated detailed description of the plant at Marvel, Ala. A steel viaduct, steel tipple with screens and interesting up-to-date equipment. 2500 w. Mfrs' Rec—May 20, 1909. No. 4764.

Peru.

The Anthracite of Huayday, Otuzco, Peru. Ernesto du B. Lukis. Describes the deposits. 1300 w. Min Jour—May 15, 1909. No. 4956 A.

Philippines.

The Coal Resources of the Philippine Islands. Warren D. Smith. Considers the importance of the coal supply, the geology, distribution, coal fields, character of the coals. Map. 4000 w. Ec-Geol—April, 1909. No. 4671 D.

Safety Lamps.

Self-Igniting Safety Lamps (Die Cereisen- und Explosivpillenzündung bei Sicherheitslampen) J. Mayer. Describes tests and experience with the recently patented Fillunger self-igniting lamp. Serial. 1st part. 4800 w. Oest Zeitschr f Berg u Hüttenwesen—April 10, 1909. No. 4865 D.

Washing.

A New Coal Washery in Michigan. Lee Fraser. Describes specially designed methods used for coal averaging about 15 per cent ash, and containing a quantity of crystallized pyrites. 800 w. Eng & Min Jour—May 15, 1909. No. 4684.

West Virginia.

Raleigh County Mining Methods. H. H. Stoek. Describes methods in use and proposed in a newly developed region of West Virginia. Ills. 4500 w. Mines & Min—May, 1909. No. 4481 C.

COPPER.

Alaska.

The Big Bonanza Copper Mine, Latouche Island, Alaska. Francis Church Lincoln. History and detailed description of its development. Ills. 2800 w. Ec-Geol—April, 1909. No. 4669 D.

See also same title, under RAILWAY ENGINEERING, MISCELLANY.

Arizona.

Mining in Western Arizona and Eastern California. W. A. Root. Map and illustrated description of properties in this region. The prevailing mineral is copper carrying gold values. 1500 w. Min Wld—May 15, 1909. No. 4700.

California.

See Arizona, under COPPER.

Electro-Metallurgy.

Recent Advances in the Electrometallurgy of Copper (Neuerungen auf dem Gebiete der Elektrometallurgie des Kupfers). Dr. Franz Peters. Discusses electrothermic methods of smelting and electrolytic refining. 3500 w. Glückauf—April 10, 1909. No. 4870 D.

Nevada.

The Yerington Copper Mining District, Nevada. Frederick L. Ransome. Abstract of a report of the general geology of the region with description of the mines. Map. 4500 w. Min Wld—May 1, 1909. No. 4398.

Production.

Copper Production in 1908 and the Present Outlook. John B. C. Kershaw. An examination of production and price statistics of the last nine years. 2000 w. Elec Rev, N Y—May 1, 1909. No. 4380.

Smelter Fumes.

Legal Status of Works Producing Noxious Gases. Charles Baskerville. Discusses phases of the smelter smoke problem in the United States. 3500 w. Eng & Min Jour—May 1, 1909. No. 4382.

Washington.

See same title, under GOLD AND SILVER.

GOLD AND SILVER.

Amalgamation.

Increasing the Efficiency of Plate Amalgamation by Electrochemical Action. Elmer Ellsworth Carey. Outlines an electrochemical system of amalgamation designed to extract from sands or pulp all gold values not encased. 2000 w. Elec-Chem & Met Ind—May, 1909. No. 4510 C.

Electro-Chemical Amalgamation. Elmer Ellsworth Carey. A discussion of gold extraction by amalgamation, especially the paper of C. G. Warnford Lock, read before the Inst. of Min. & Met. some sixteen years ago. 2000 w. Min Jour—May 15, 1909. No. 4958 A.

Australia.

Mining Costs and Labor in Western Australia. Richard Hamilton. Abstract of an address at meeting of the Chamber of Mines of Western Australia. Discusses ways in which the workers may co-operate toward reducing working costs. 2500 w. Min Jour—May 1, 1909. No. 4611 A.

Mining in Victoria. E. J. Dunn. Brief review of mines in the auriferous district known as the St. Arnaud field. 3500 w. Aust Min Stand—March 31, and April 7, 1909. 2 parts. No. 4616 each B.

Southern End of the Bendigo Goldfield. Donald Clark. Describes the Goldfields line of reef and the mines now being worked. 1500 w. Aust Min Stand—April 7, 1909. No. 4618 B.

The Etheridge Goldfield, Queensland. W. C. Walworth Pearce. Describes a field where copper, lead, gold and silver have been found, being brought to notice by new railway construction. Map. 2500 w. Min Jour—May 1, 1909. No. 4610 A.

Chlorination.

Dry Chlorine Processes. F. W. Traphagen. Explains methods used for the chlorination of complex ores containing precious metals, with zinc, lead, and iron. 4000 w. Mines & Min—May, 1909. No. 4479 C

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Cobalt.

Eastern Canada. Alex. Gray. Reviews a years work at the Nipissing, the present position and recent development. 3000 w. Min Jour—May 1, 1909. No. 4613 A.

Consolidation of the La Rose-Lawson Properties. Alex. Gray. An account of an event of importance in the mining development at Cobalt, Ont. 1800 w. Min Wld—May 8, 1909. No. 4580.

Coinage.

Coinage in the British Empire. J. J. Harpell. Deals particularly with the British minting system. 2200 w. Can Min Jour—May 15, 1909. No. 4771.

Cyaniding.

Cyanidation of Silver Ores. D. Mosher. Considers the need of methods that will give greater range in the treatment of low-grade silver ores. 2500 w. Min & Sci Pr—May 15, 1909. No. 4791.

Cyanidation at Mercur, Utah. Leroy A. Palmer. Describes the ores and method of treatment. Ill. 3000 w. Min & Sci Pr—May 1, 1909. No. 4528.

See also Precipitation, under GOLD AND SILVER.

Dredging.

Examination of Gold Dredging Properties. T. S. Ruh. Comments on methods that cause failure. 1000 w. Eng & Min Jour—May 1, 1909. No 4384.

Testing Dredgeable Gravels. William H. Radford. Suggestions for testing and working placers. Ills. 3500 w. Min & Sci Pr—May 22, 1909. No. 5010.

The Dredging Industry in New Zealand. Arthur C. Buckland. Describes the present condition and the outlook. 3000 w. Min Jour—May 1, 1909. No. 4612 A.

Failures in Spuds. Howard D. Smith. On the care that should be taken to provide for the strains in these long steel beams used to hold gold dredges against the bank. Ills. 500 w. Min & Sci Pr—May 22, 1909. No. 5012.

Restoring Dredged Ground. Abstract from a report of D. B. Sellars, concerning methods used in Victoria, Australia, to restore the dredged area to usefulness for agricultural purposes. Ills. 1200 w. Eng & Min Jour—May 8, 1909. No. 4567.

Electro-Metallurgy.

Recent Advances in the Electro-Metallurgy of the Precious Metals and of Lead (Neuerungen auf dem Gebiete der Elektrometallurgie der Edelmetalle und des Bleis). Dr. Franz Peters. Discusses cyaniding and refining processes for gold and silver, and smelting and refining processes for lead. Ills. 4500 w. Glückauf—April 17, 1909. No. 4871 D.

Germany.

See same title, under LEAD AND ZINC

Gold Mining.

The "Wholesale" Idea of Gold Mining. W. R. Feldtmann. Discusses the policy of increasing reduction plant, up to the practicable producing limit of a mine, indicating the relation between large scale working and the best economic results. 5000 w. Inst of Min & Met, Bul. 55—April 15, 1909. No. 4737 N.

Korea.

See same title, under MISCELLANY.

Mexico.

Calabacillas Gold Mine. Brief account of this mine on the west coast of Mexico, the methods of development, and character of the ore deposits. Ills. 1000 w. Min & Sci Pr—May 15, 1909. No. 4790.

Nevada.

See Silver Milling, under ORE DRESSING AND CONCENTRATION.

New Mexico.

See same title, under LEAD AND ZINC.

New Zealand.

See Dredging, under GOLD AND SILVER.

Ontario.

Impressions of a New Ontario Camp—Gowganda. H. E. West. Describes the deposits, and considers railroad connections essential to their development. 3000 w. Eng & Min Jour—May 1, 1909. No. 4385.

Placers.

The Placer Mining Industry of North Carolina. R. Kemp Welch. Reviews the history of the industry and gives information in regard to mines now being worked. Ills. 2500 w. Min Wld—May 22, 1909. No. 4934.

Precipitation.

Notes on Precipitation. Mather Smith. A critical discussion of methods, aiming to show that more zinc than is necessary is used and is both harmful and costly; and that precipitation boxes are often constructed on a wrong principle. 2500 w. Jour Chem, Met & Min Soc of S Africa—March, 1909. No. 4974 E.

Rand.

See Valuation, under MINING.

Siberia.

Gold and Other Minerals of Eastern Siberia. S. F. G. White. Reports rich gold quartz veins in Backal; placer deposits in Amurski Oblast. 2000 w. Eng & Min Jour—May 22, 1909. No. 4918.

Transvaal.

The Pilgrim's Rest Gold Fields and Mining Methods. J. Moyle-Phillips. Illustrates and describes the geology and methods of development, giving the history of these mines. 6000 w. Jour Chem, Met, & Min Soc of S Africa—March, 1909. No. 4973 E.

Washington.

Developments in the Orient District, Washington. Bert N. Sharpe. An illustrated account of this district which yields ores carrying gold, silver and copper. 1200 w. Min Wld—May 8, 1909. No. 4581.

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IRON AND STEEL.

Blast-Furnace Plants.

The Lübeck Iron Works (Das Hochofenwerk Lübeck). Illustrated detailed description. 3000 w. Stahl u Eisen—April 28, 1909. No. 4859 D.

Blast-Furnace Practice.

On Charcoal Blast-Furnace Practice in the Ural. M. A. Pavloff. Gives some numerical data relating to the seven blast furnaces in the Ural region. 3500 w. Engr, Lond—May 14, 1903. No. 4967 A.

Stock Distribution for Blast Furnaces. J. E. Johnson, Jr. Describes a new method of rotating and dumping the ball. Ills. 2000 w. Ir Age—May 13, 1909. No. 4636.

Blast-Furnace Slag.

Economies in the Manufacture of Iron and Steel. G. B. Waterhouse. The second of two articles dealing with the two great economies. The present number considers the utilization of blast-furnace slag, especially in the manufacture of cement. Ills. 4000 w. Engineering Magazine—June, 1909. No. 4985 B.

Blowing Engines.

The Two-Cycle Gas-Blowing Engine Plant at the Works of the Frodingham Iron and Steel Company, Limited. Plate, illustrations and description. 1500 w. Ir & Coal Trds Rev—May 7, 1909. No. 4734 A.

See also Air Compressors, and Turbo-Compressors, under MECHANICAL ENGINEERING, POWER AND TRANSMISSION.

Cost.

Cost of Iron Production in Britain and America. A criticism of recent statements made by Mr. Andrew Carnegie. 2500 w. Engr, Lond—May 7, 1909. No. 4729 A.

Electro-Metallurgy.

The Heroult Electric Steel Furnace. Robert Turnbull. Reviews the history, illustrating and describing features. 1500 w. Ir Age—May 13, 1909. No. 4638.

Small Experimental Heroult Furnace. C. A. Hansen. Illustrated description of the furnace and the results obtained. 1500 w Elec-Chem & Met Ind—May, 1909. No. 4508 C.

Electric Smelting. F. W. Harbord. Abstract of a paper read at meeting of the W. of Scotland Ir & Steel Inst. Deals particularly with the results obtained. 4500 w. Elec Engr, Lond—May 7, 1909. No. 4715 A.

The Electric Furnace Reduction of Iron Ore. Joseph W. Richards. Read before the Am. Elec.-Chem. Soc. Considers the reactions in blast furnaces and the differences in electric furnace smelting of iron ores. 2500 w. Ir Trd Rev—May 15, 1909. No. 4642.

The American Electrochemical Society. Report of the meeting at Niagara Falls, Canada, on May 5, giving abstracts of papers read. Many dealt with the electrometallurgy of iron and steel. 9000 w. Ir Age—May 13, 1909. No. 4637.

Ingot Compression.

Fluid Compression of Steel Ingots. J. F. S. Springer. An illustrated description of the Harmet process and the fluid-compression presses used. 1200 w. Sci Am—May 29, 1909. No. 5024.

Ontario.

Report on the Examination of Some Iron Ore Deposits in the Districts of Thunder Bay and Rainy River, Province of Ontario. F. Hille. Enumerates and describes the various ore deposits. Maps & Ills. 21500 w. Can Dept of Mines—No. 22. No. 4542 N.

Production.

Iron and Steel Production in Recent Years. Editorial review of statistics from the Board of Trade publication, in regard to the principal countries. 2000 w. Engng—May 14, 1909. No. 4964 A.

Rolling Mills.

Gas Power for Rolling Mills. Dr. Franz Erich Junge. A discussion limited to a large modern combined iron and steel works embracing all the departments necessary to transform ore into finished product. Ills. 6000 w. Ir Trd Rev—May 13, 1909. No. 4641.

See also Electric Driving, under MECHANICAL ENGINEERING, POWER AND TRANSMISSION; and Rails, under RAILWAY ENGINEERING, PERMANENT WAY AND BUILDINGS.

Steel Works.

Some Observations on Structural Shop Management. Samuel E. Duff. Discusses the principles of accurateness as applied to shop management. Also general discussion. 8500 w. Pro Engrs' Soc of W Penn—April, 1909. No. 4555 D.

Sweden.

Technical, Social and Economic Aspects of Ironstone Mining in Sweden, Its Prospects and Probable Development (Schwedens Eisensteinbergbau in technischer, sozialer und wirtschaftlicher Hinsicht, seine Aussichten und vermutliche Entwicklung). Herr Spackeler. Ills. Serial. 1st part. 4200 w. Glückauf—April 3, 1909. No. 4869 D.

Tin Plates.

The Manufacture of Tin Plates and Terne Plates. William G. Gray. Read before the Phila. Master Tin & Sheet Metal Workers' Assn. Gives the history of this industry and statistics relating to it. 4500 w. Ir Age—May 20, 1909. No. 4769.

Tube Making.

The Making of a Cold-Drawn Steel Tube. Illustrated description of the Shelby Process. 3000 w. Sci Am Sup—May 8, 1909. No. 4541.

We supply copies of these articles. See page 723.

United States.

The American Iron and Steel Industry. T. Good. A British view of the American trade. 4500 w. Cassier's Mag—May, 1909. No 4404 B.

LEAD AND ZINC.

Germany.

Silver-Lead Mining in Freiberg, Germany. Wilton G. Brown. Gives the history of mining in this region, beginning in the 12th century. 2500 w. Eng & Min Jour—May 15, 1909. No. 4683.

Lead Milling.

Concentrating Difficult Lead Ores at Broken Hill. Gerard W. Williams. Describes methods used at Block 10 mill for treating rhodonite-bearing ores. 2500 w. Eng & Min Jour—May 8, 1909. No. 4565.

Lead Refining.

See Electro-Metallurgy, under GOLD AND SILVER.

Lead Smelting.

Modern Silver-Lead Smelting at Laurium, Greece. Henry F. Collins. Describes the ore treatment, and the new American blast furnace installed. Ills. 2500 w. Eng & Min Jour—May 1, 1909. No. 4381.

Massachusetts.

See Ore Deposits, under MISCELLANY.

Missouri.

Migrations of the Joplin Zinc Belt. Charles R. Keyes. Diagrams and outline of geologic history. 1000 w. Eng & Min Jour—May 22, 1909. No. 4922.

New Mexico.

The Tres Hermanas Mining District, New Mexico. Waldemar Lindgren. Abstract from Bul. U. S. Geol. Surv. Describes veins rich in lead and gold, with deposits of zinc, and the general geologic formation. 2000 w. Min Wld—May 8, 1909. No. 4579.

MINOR MINERALS.

Amatrice.

Amatrice, a New Gem Stone of Utah. Edward R. Zalinski. A matrix stone, consisting of the minerals variscite and chalcedony, with wardite or possibly other hydrous aluminum phosphates and quartz. Ills. 2000 w. Eng & Min Jour—May 22, 1909. No. 4920.

Antimony.

Antimony. E. B. Wilson. Its uses, ores, methods of testing, etc., are discussed. 3000 w. Mines & Min—May, 1909. No. 4482 C.

Carborundum.

The Works of the Carborundum Company at Niagara Falls. An illustrated sketch of recent developments. 1600 w. Elec-Chem & Met Ind—May, 1909. No. 4504 C.

Cement.

Portland Cement. John L. Howard. Read before the Berkeley Club. Reviews the discoveries that mark the development of this material. 4500 w. Min & Sci Pr—May 1, 1909. No. 4530.

Critical Economies in Portland Cement Production. E. A. Richmond. Discusses the best length and diameter for kilns, effects of fine grinding, costs, etc. 2500 w. Eng Rec—May 15, 1909. No. 4694.

The Mills of the Cowell Portland Cement Company. Illustrated description of a mill near San Francisco, with a capacity of 4000 barrels per day. 3500 w. Eng Rec—May 8, 1909. No. 4575.

See also Blast Furnace Slag, under IRON AND STEEL.

Diamonds.

The Diamond Bearing Highlands of Bahia. J. C. Branner. Illustrates and describes this region in Brazil, outlining the geology, describing the diamond producing area, and mining methods used. 4000 w. Eng & Min Jour—May 15, 1909. Serial. 1st part. No. 4682.

Supposed Diamond-Bearing Volcanic Pipe. E. F. Pittman. An account of a supposed diamatiferous deposit at Snodgrass, Australia. 2000 w. Aust Min Stand—April 7, 1909. No. 4617 B.

Graphite.

The Work of the International Achison Graphite Company at Niagara Falls. Illustrates and describes the present equipment of these works. 1800 w. Elec-Chem & Met Ind—May, 1909. No. 4503 C.

See also same title, under ORE DRESSING AND CONCENTRATION.

Mica.

Mica Mining. A. S. Atkinson. Remarks on the increased value of mica deposits, the mining methods in the United States and Canada, etc. 1600 w. Eng & Min Jour—May 8, 1909. No. 4566.

Natural Gas.

Long Distance Pumping of Natural Gas. Snowden B. Redfield. Illustrates and describes the gas-pumping and compression plants, employing gas engines to drive the compressors. 2500 w. Am Mach—Vol. 32. No. 21. No. 5015.

Oil.

Some Petroleum-Bearing Regions of Mexico. Juan D. Villarello. Brief reports of the various districts, with general conclusions. 2000 w. Min Jour—May 15, 1909. No. 4955 A.

Bitumen and Oils in West Africa. T. Hugh Boorman. Information concerning the deposits. 1200 w. Eng & Min Jour—May 22, 1909. No. 4919.

New Method of Extracting Oil from Boreholes. Frederick A. Talbott. The principal feature is an endless cable covered with absorbent material and operated from a drum at the surface. 2000 w. Eng & Min Jour—May 15, 1909. No. 4686.

The "Liming" of Crude Oil. A. P. Lidoff. Explains the advantages of a proposed

new method. 1800 w. Min Wld—May 22, 1909. No. 4938.

See also Formation, under COAL AND COKE.

Platinum.

The Russian Platinum Industry and Its Regulation. E. De Hautpick. Gives statistics of output and consumption, discussing the dissatisfaction of producers, and proposed legislation. 3000 w. Min Jour—May 8, 1909. No. 4722 A.

Rare Metals.

The Occurrence of the Rare Metals in Peru. Eugen Weckwarth. Abstract translation. Cerium, germanium, lithium, molybdenum, rubidium, thalium, tellurium, titanium, thorium, tungsten, vanadium, and zirconia have been found. 1500 w. Min Jour—April 24, 1909. No. 4456 A.

Tantalum.

Tantalum and Its Industrial Applications. Alex. Siemens. Lecture at the Roy. Inst. Reviews the investigations of metallic filaments, and the experiments with tantalum, and many other ores showing its remarkable qualities. 3000 w. Nature—May 6, 1909. No. 4702 A.

Tin.

Tin in the Black Hills of South Dakota. Jesse Simmons. Brief description of the geology and development. Ills. 1500 w. Min Wld—May 15, 1909. No. 4699.

Some Features of the Alaskan Tin Deposits. Adolph Knopf. Describes the mode of occurrence and the associated minerals, the geology, and mineralization. 3000 w. Ec-Geol—April, 1909. No. 4670 D.

Trass.

The Genesis, Mining and Uses of Trass (Der Trass, seine Enstehung, Gewinnung und Bedeutung im Dienste der Technik). Herr Hambloch. Ills. 6600 w. Zeitschr d Ver Deutscher Ing—April 24, 1909. No. 5079 D.

Tungsten.

Tungsten in Colorado. H. R. Wagenen. The Frenzel prize thesis. Discusses its occurrence, mill practice, production, etc., its physical properties, uses, mineralogy, chemistry and other topics. 13500 w. Qr of Colorado Sch of Mines—April, 1909. No. 4741 N.

MINING.

Accounting.

Mining Accounts. Dwight B. Huntley. A lecture delivered before the Mining Assn. of the Univ. of Cal. on the keeping of mining accounts. 4500 w. Cal Jour of Tech—April, 1909. No. 4761.

Deep Level.

Suggestions for Modern Deep Level Mining. H. H. Johnson and H. F. Roche. Gives an outline of the writer's views on the surface equipment only, in the present article. General discussion. Ills. 4500 w. Jour S African Assn of Engrs—March, 1909. No. 4445 A.

Diamond Drilling.

See Prospecting, under MINING.

Drills.

Surface Trials in Rand Stope Drill Competition. Eustace M. Weston. Report of results of trials held under the auspices of the Transvaal government. 2500 w. Eng & Min Jour—May 15, 1909. No. 4685

Electric Power.

Electricity in Mines (L'Electricité dans les Mines). Albert Rigaux. The first part discusses the generation and distribution of electrical energy. Ills. Serial. 1st part. 7500 w. Bul Sci d l'Assn des Eléves —March, 1909. No. 4806 D.

Head Frames.

Stresses in Hoisting Ropes and the Design of Mine Headgears. Robert Boyle. Drawings and discussion. 11700 w. Scottish Inst of Min Students—May 16, 1908. No. 4758 N.

Hoisting.

Counterbalanced Hoisting. R. L. Herrick. Illustrates and describes ingenious devices used in Colorado mines which result in economy of power. 3300 w. Mines & Min—May, 1909. No. 4477 C.

See also Head Frames, under MINING.

Hoisting Engines.

Three Thousand Horse Power Winding Engine. J. B. Van Brussel. Illustrates detailed description of a high pressure type. 800 w. Eng & Min Jour—May 1, 1909. No. 4386.

Methods.

Underground Mining. Edgar Taylor. Presidential address briefly reviewing ancient and modern methods. 4000 w. Inst. of Min & Met, Bul. 55—April 15, 1909. No. 4735 N.

Mine Reports.

Geologic Essentials of a Mine Report. Courtenay De Kalb. An address before the Geol. Soc. of Stanford Univ. A discussion of the essential points and other related topics. 4500 w. Min & Sci Pr—May 1, 1909. No. 4529.

Ore Bins.

Mechanical Devices for Filling Ore Bins (Anlagen zur mechanischen Beschickung von Erztaschen). L. Schütt. Describes devices for handling and dumping cars at the Pont-à-Mousson iron works, France. Ills. Serial. 2 parts. 2200 w. Stahl u Eisen—April 7, 1909. No. 4857 each D.

Prospecting.

Diamond Drill Prospecting in Southeast Missouri. Otto Ruhl. An account of the setting up of the machines, prospecting methods, etc. Ills. 2200 w. Min Wld—May 1, 1909. No. 4396.

Pumps.

Sinking Pumps. Frank S. Mitchell. Illustrated description of a design. 1000 w. Jour Assn of Engng Socs—March, 1909. No. 4911 C.

We supply copies of these articles. See page 723.

Valuation.

The Computation of the Present Value of Developed and Undeveloped Mines. W. H. Goodchild. Paper before the Inst. of Min. & Met. Deals mainly with the computation of the present gross value. 3800 w. Ir & Coal Trds Rev—April 23, 1909. No. 4473 A.

The Valuation of Mining Areas on the Rand. W. Fischer Wilkinson. Considers the factors that decide the size of a mine and the principles of valuation. 2800 w. Inst of Min & Met., Bul. 55—April 15, 1909. No. 4736 N.

ORE DRESSING AND CONCENTRATION.

Drying.

The Technique of Desiccation. O. Bechstein, in *Prometheus*. Illustrates and describes apparatus for the artificial drying of agricultural products and wastes. 2500 w. Sci Am Sup—May 22, 1909. No. 4906.

Calculations for Dryer Design. William M. Grosvenor. Presented at meeting of Am. Inst. of Chem. Engrs. With humidity chart supplement, and tables. 4000 w. Heat & Vent Mag—May, 1909. No. 4929.

Evaporators.

The Evaporator. Edward Zaremba. Describes the vacuum apparatus, presenting its advantages. 1400 w. Elec Chem & Met Ind—May, 1909. No. 4509 C.

Gold Milling.

Milling in the Cripple Creek District, Colorado. S. A. Worcester. Discusses causes of failure in past milling operations, offering suggestions for successful plants. 2500 w. Eng & Min Jour—May 8, 1909. No. 4569.

New Type of Washer for Low-Grade Gold Ores. Joseph Hyde Pratt. Illustrated description of a machine found superior to other types for treating the gold ores of the South Atlantic States. 2000 w. Eng & Min Jour—May 8, 1909. No. 4564.

See Amalgamation, and Cyaniding, under GOLD AND SILVER.

Graphite.

Graphite Concentration. H. P. H. Brumell. A résumé of work done in Canada, with brief illustrated descriptions of various plants. 4000 w. Can Min Jour—May 1, 1909. No. 4490.

Lead Milling.

The Concentration of Silver-Lead Ores, Broken Hill. U. F. Stanley Low. Gives details of methods adopted at Block 10 Co.'s works. Ills. 5500 w. Aust Min Stand —March 31, 1909. Serial. 1st part. No. 4615 B.

Metallurgical Treatment of Jamesonite Ores. G. P. Ives and I. D. Ossa. Abstract of a thesis submitted to the faculty of the S. D. State Sch. of Mines. Describes these ores of value for the metals lead and antimony, also gold and silver, and their treatment. 1200 w. Eng & Min Jour —May 1, 1909. No. 4383.

Magnetic Concentration.

The Concentration of Low-Grade Magnetic Iron Ores. G. C. MacKenzie. Considers important features of the problem. 3500 w. Ir Trd Rev—May 6, 1909. No. 4535.

The Magnetic Separation of Ores and Its Application to Spathic Iron (Siderite) in Siegerland. W. J. Bartsch. Abstract of a paper read at meeting of the Assn. "Berggeist" at Siegen. Explains the principles of separation, illustrating and describing the Brüderbund mines plant. 3000 w. Ir & Coal Trds Rev—May 7, 1909. No. 4732 A.

Magnetic Concentration of Iron Ores, Ontario. George C. Mackenzie. Abstract from report of Bureau of Mines, Toronto. A discussion of the concentration problem and proposed methods. 2500 w. Min Wld —May 8, 1909. No. 4582.

See also Tungsten, under ORE DRESSING AND CONCENTRATION.

Silver Milling.

Mines and Plants of the Pittsburg Silver Peak. Henry Hanson. An illustrated discussion of the milling practice at these mines in Nevada. Ills. 3500 w. Min & Sci Pr—May 8, 1909. No. 4652.

Tungsten.

The Separation of Tungsten Minerals. Henry E. Wood. Abstract of paper read before the Colo. Sci. Soc. Considers wet concentration and magnetic separation, favoring the latter where it is possible to use it. 1500 w. Min Wld—May 22, 1909. No. 4935.

MISCELLANY.

Australia.

The Queensland Mining Industry. A review of the year 1908. Report of A. R. Macdonald, Under Secretary for Mines. 24500 w. Queens Gov Min Jour—April, 1909. No. 4745 B.

Canada.

The Occurrence and Mining of Coal and Metals in Canada (Vorkommen und Gewinnung von Kohle und Erz in Kanada). Ernst Kraynik. Report of one of the German representatives on the recent tour of the Canadian Mining Institute. Ills. Serial. 1st part. 5500 w. Glückauf—April 24, 1909. No. 4872 D.

Colorado.

Geology of the Mineral Resources of Colorado. Arthur Lakes. Briefly considers coal, artesian wells, clays, cement, building and flag stones, silver, lead and gold, marble, some rare metals and petroleum. 2500 w. Min Wld—May 22, 1909. No. 4936.

Crystallography.

Peculiar Crystalline Forms of Minerals and Metals. Arthur Lakes. Illustrated descriptions of interesting specimens. 1500 w. Min Wld—May 1, 1909. No. 4397.

We supply copies of these articles. See page 723.

Geological Survey.

The Technologic Branch of the United States Geological Survey. George S. Rice. An illustrated article explaining its work and aims, and describing the experimental plant at Pittsburg. 5000 w. Mines & Min—May, 1909. No. 4476 C.

Korea.

Mining in Korea. Abstract of a consular report by Mr. Sammons. Considers the mining laws and regulations, and the gold mines and placers in the present article. 2500 w. Min Jour—May 15, 1909. Serial. 1st part. No. 4957 A.

Ore Deposits.

The Lead-Silver Deposits at Newburyport, Massachusetts, and Their Accompanying Contact-Zones. C. H. Claff and W. G. Ball. Gives the history, topography, general geology, describing ore deposits and their origin. 3800 w. Ec-Geol—April, 1909. No. 4672 D.

United States.

Mines and Minerals in the New England States. C. W. Kempton. Brief illustrated description of ore deposits discovered. 1200 w. Min Wld—May 1, 1909. No. 4399.

RAILWAY ENGINEERING.

CONDUCTING TRANSPORTATION.

Signaling.

Government Report of Block Signal Mileage. Information from a bulletin recently issued by the Interstate Commerce Commission. 4000 w. R R Age Gaz—May 14, 1909. No. 4658.

Failures of Signal Apparatus, Reporting, Repairing, Recording. H. S. Balliet. Explains the system in effect on the electric division of the N. Y. C. & H. R. railroad. 3500 w. Sig Engr—May, 1909. No. 4701.

The Appeal of the Railway Signal. Brief explanation of the principles of the automatic signal and of the interlocking system, describing the systems discussed at the recent Chicago meeting of the Ry. Sig. Assn. Ills. 1200 w. Ry & Loc Engng—May, 1909. No. 4416 C.

Electric Train Staff on the Southern Pacific. An account of this system and its operation. 2500 w. R R Age Gaz—May 21, 1909. No. 4900.

Recent Practice in the Interlocking of Railway Points and Signals (Les Procédés les plus récents d'Enchenchements des Signaux et des Aiguilles). M. A. Moutier. Describes the mechanism and operation of various recent types of signalling apparatus. Ills. 8400 w. Mem Soc Ing Civ de France—Feb., 1909. No. 4808 G.

See also Signal Lamps, under ELECTRICAL ENGINEERING, LIGHTING.

Train Weights.

The Maximum Weights of Slow Freight Trains. Discussion of C. S. Bissell's paper. 1000 w. Pro Am Soc of Civ Engrs—May, 1909. No. 5111 E.

MOTIVE POWER AND EQUIPMENT.

Air Brakes.

Leak at H6 Brake Valve. Explains some air brake tests. 2500 w. Ry & Loc Engng—May, 1909. No. 4420 C.

Development in Air Brakes for Railroads with a Brief Review of Past and Present Operating Conditions. W. V. Turner and S. W. Dudley. On the development and present state of the air-brake art. Also discussion. Ills. 45000 w. Pro N Y R R Club—April 16, 1909. No. 4756.

Axle Boxes.

Questions of Economy and Improvement in Axle Boxes for Railway Rolling Stock (Einiges zur Verbesserungs- und Wirtschaftlichkeitsfrage der Achsbüchsen der Eisenbahn-Betriebsmittel.) Herr Erdbrink. An exhaustive and elaborately illustrated discussion. 8000 w. Glasers Ann—April 15, 1909. No. 5056 D.

Car Lighting.

See Hand Lamps, under ELECTRICAL ENGINEERING, LIGHTING.

Electrification.

Presidential Address before the Institution of Mechanical Engineers. John A. F. Aspinwall. A general discussion of the electrification of steam railways. Ills. 11000 w. Inst of Mech Engrs—April 23, 1909. No. 4558 N.

Developments in Electrification of Railway Terminals. H. H. Evans. A discussion of the advantages, the economies gained and the factors that lead to electrification. General discussion. 30000 w. Jour W. Soc of Engrs—April, 1909. No. 4787 D.

Discussion on "The Log of the New Haven Electrification." New York, Dec. 11, 1908. 27000 w. Pro Am Inst of Elec Engrs—May, 1909. No. 4994 F.

The Electrification of the Heysham, Morecombe and Lancaster Branch of the Midland Railway. Em. Uytborck. Describes the various installations, calling attention to the special peculiarities. Ills. 5800 w. Bul Int Ry Cong—April, 1909. No. 4981 G.

Freight Cars.

Four-Hopper Steel Coke Car. Illustrated description of a new design for the Pennsylvania R. R. 800 w. Am Engr & R R Jour—May, 1909. No. 4421 C.

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Locomotive Boilers.

Circulation in Locomotive Boilers. Roger Atkinson. A description of the movement set up by heat and the arrangements that have been tried to improve it. 1800 w. Ry & Loc Engng—May, 1909. No. 4419 C.

Locomotive Construction.

The Conditions of Locomotive Building in the United States, Germany and France (Note sur les Conditions de Construction des Locomotives aux Etats-Unis, en Allemagne et en France). Marcel Bloch. A comparison of conditions for rapid and cheap locomotive building. 15000 w. Rev Gen d Chemins de Fer—April, 1909. No. 4822 G.

Locomotive Efficiency.

See Train Speed, under MOTIVE POWER AND EQUIPMENT.

Locomotive Fireboxes.

The Jacobs-Shupert Locomotive Firebox. Illustrated detailed description of a radical departure from the usual construction. Also editorial. 3000 w. R R Age Gaz—May 28, 1909. No. 5047.

Locomotive Fuels.

Influence of Ash on Value of Coal in Locomotive Service. A. Bement. A brief report of experiments, introducing a discussion of this subject. 4000 w. Pro W Ry Club—April 20, 1909. No. 4757 C.

Locomotive Oscillations.

Locomotive Oscillations with Respect to the Play of the Springs (Das Wanken der Lokomotiven unter Berücksichtigung des Federspieles). J. Jahn. A mathematical discussion. Ills. Serial. 1st part. 5000 w. Zeitschr d Ver Deutscher Ing—April 3, 1909. No. 5070 D.

Locomotive Rating.

Tonnage Rating and Efficiency. A. W. Vestal. A discussion of the influences that must be considered in determining the most efficient rating of engines. 1600 w. Ry & Loc Engng—May, 1909. No.4417 C.

Locomotive Repairs.

Locomotive Repair Shop Practice. Ethan Viall. Illustrates and describes methods used in the Chicago shops of the C. & N. W. Ry. 3300 w. Mach, N Y—May, 1909. No. 4424 C.

Locomotives.

A New Departure in Locomotive Construction. Illustrates a novel type of steam locomotive using liquid fuel, constructed by Arthur Koppel for use on an industrial railway. 500 w. Sci Am Sup—May 29, 1909. No. 5026.

Pacific and Atlantic Type Locomotives. Illustrations, elevations, sections and description of engines for the Northern Pacific Ry. 1000 w. Am Engr & R R Jour—May, 1909. No. 4422 C.

4-6-0, for the Chicago, Milwaukee & Puget Sound Railway. Illustrated description of engines known as G-6, for handling the heaviest and fastest passenger trains. 1000 w. Ry & Loc Engng—May, 1909. No. 4418 C.

British Locomotive Building. From evidence of J. F. Robinson before the British Tariff Commission. Gives information in regard to the export trade, raw materials, standardization, etc. 4400 w. R R Age Gaz—May 7, 1909. No. 4559.

British Locomotives in 1908. J. F. Gairns. A review of the designs and performance. Ills. 7900 w. Bul Int Ry Cong—April, 1909. No. 4980 G.

Express Passenger Locomotives, North-Eastern Railway. Plate and dimensions of engines for heavy express traffic. 700 w. Engr, Lond—April 23, 1909. No. 4469 A.

Express Locomotive; Paris-Orleans Railway Company, France. Plate and illustrated detailed description of engines for fast express service in France, built in America. 2000 w. Engng—April 30, 1909. No. 4624 A.

The New 2/5 Coupled Express Locomotive of the Prussian State Railways (Die neuen 2/5-gekuppelten Schnellzug-lokomotiven der Preussichen Staatsbahn). Herr Metzeltin. Illustrated description. Serial. 1st part. 5000 w. Zeitschr d Ver Deutscher Ing—April 24, 1909. No. 5076 D.

Locomotive Speed.

See Speed Indicators, under MECHANICAL ENGINEERING, AUTOMOBILES.

Locomotive Valve Gears.

American Balanced Valves. Illustrates and describes two designs,—one is a flat slide and the other a piston valve. 1500 w. R R Age Gaz—May 21, 1909. No. 4799.

Motor Cars.

A New Type of Gasoline-Electric Car. Illustrated description of a recent design of the General Electric Co. 1000 w. Elec Ry Jour—May 29, 1909. No. 5102.

The Maffei Steam Motor Coach. Illustrated description of a motor car for the Bavarian state railroads, which shows novel features. 800 w. Sci Am Sup—May 15, 1909. No. 4639.

New Stover Motor Car. Illustrated description of a 25-passenger gasoline motor car for the C., R. I., & P. Ry. 1000 w. Ry & Engng Rev—May 8, 1909. No. 4578.

Shops.

The Railway Workshops, Ipswich, O. Illustrated description of the equipment of one of the finest of modern workshops in Australasia. 1500 w. Aust Min Stand—April 7, 1909. No. 4620 B.

Snow Plows.

See Snow Handling, under PERMANENT WAY AND BUILDINGS.

Train Lighting.

Train Lighting at 110 Volts by Turbo-Generator on Locomotives. Illustrated description of the new equipment adopted on the suburban trains of the C., B. &

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Q. R. R. 700 w. Elec Wld—April 8, 1909. No. 4432.

Train Resistance.

Train Resistance. A. Stucki. Considers the different elements entering into train resistance, and the conditions under which each will appear. 2500 w. R R Age Gaz—May 7, 1909. No. 4562.

Train Speed.

A Simple Method of Determining Train Speed from Locomotive Efficiency (Ueber ein einfaches Verfahren zur Ermittlung der Fahrzeiten der Eisenbahnzüge nach der Leistungsfähigkeit der Lokomotiven). Erwin Lihotzky. A mathematical demonstration. Ills. Serial. 1st part. 2000 w. Zeitschr d Oest Ing u Arch Ver—April 9, 1909. No. 4891 D.

Wheels.

Car Wheel Forging and Conditions of Steel for High Service. Jas. H. Baker. Illustrates and describes methods, explaining their advantages. General discussion. 8000 w. Pro Engrs' Soc of W Penn—April, 1909. No. 4554 D.

NEW PROJECTS.

Canadian Pacific.

Sudbury-Kleinburg Branch of the Canadian Pacific. F. S. Darling. A new line in the Georgian Bay region of Ontario is illustrated and described, and information given concerning conditions. 1600 w. R R Age Gaz—May 14, 1909. No. 4659.

Chile.

The Arica-La Paz Railway. Illustrated description of a proposed line between Chile and Bolivia, presenting engineering features of great interest. 1500 w. Engr, Lond—April 30, 1909. No. 4630 A.

England.

The Kingsbury and Water Orton Railway. Illustrated description of a new line recently opened by the Midland Railway Co., England. 2000 w. Engr, Lond—May 7, 1909. No. 4730 A.

PERMANENT WAY AND BUILDINGS.

Coaling Plants.

A Large Concrete and Timber Coal Pocket. Illustrated description of coal pockets for the Philadelphia & Reading Ry. at Philadelphia. 1500 w. Eng Rec—May 8, 1909. No. 4574.

Construction.

Railway Construction Notes. F. Pardoe Wilson. Suggestions in regard to earth shrinkage and overhaul, and the use of graders and steam shovels on railroads. Diagrams. 2000 w. Can Soc of Civ Engrs—April 15, 1909. No. 4531 N.

Hydraulic Construction of Large Embankments on the Chicago, Milwaukee & Puget Sound Ry. Illustrated detailed description of this work. 4000 w. Eng News—May 27, 1909. No. 5017.

Temporary Work on the Canadian Pacific Railway. J. Grant MacGregor. Illustrates and describes temporary work employed during construction. 4500 w. Can Engr—May 14, 1909. No. 4674.

Crossing Gates.

See same title, under STREET AND ELECTRIC RAILWAYS.

Crossings.

The Protection of Grade Crossings. Gives particulars as to British practice in the protection of highway and railway grade crossings, suggesting remedies for evils in Canada. Ills. 2500 w. Can Engr—May 21, 1909. No. 4915.

Curves.

A Discussion of Spiral Curves. Discusses formulae of the measurement of spirals and their faults. 2500 w. Eng Rec—May 15, 1909. No. 4689.

The Maintenance of the Track at Curves. Mr. Weikard. Trans. from *Organ für die Fortschritte des Eisenbahnwesens.* Discusses the cause of irregularity of curves. 1400 w. Bul Int Ry Cong—April, 1909. No. 4982 G.

Rail Fastenings.

Screw Spikes and Improvements in Rail Fastenings. Abstract of W. C. Cushing's paper in a bulletin issued by the Am. Ry. Engng. & Main. of Way Assn., with editorial discussion. Ills. 7000 w. Eng News—May 20, 1909. No. 4778.

Rails.

Comparative Rail Specifications. Gives in parallel columns five specifications for Bessemer and open hearth steel rails brought up to date, with editorial. 9500 w. R R Age Gaz—May 21, 1909. No. 4798.

A Reliable Steel Rail and How to Make It. James E. York. Considers the causes of poor quality and how a reliable quality can be made. Illustrates the York mills for solidifying ingots, and for rolling rails. 4500 w. Bul Am Inst of Min Engrs—May, 1908. No. 5002 F.

Titanium Alloy in Rails and CarWheels. Charles V. Slocum. Information concerning the remarkable improvement which titanium gives to steel and iron. Discussion. 6500 w. Pro Ry Club of Pittsburg—April 23, 1909. No. 4913 C.

Snow Handling.

Methods of Snow-Fighting on Railroads. A. W. Wheatley. Read before the Can. Ry. Club. Discusses methods of keeping the railroad open, describing the rotary snow-plow and its operation. 2500 w. Engng-Con—May 26, 1909. No. 5045.

Stations.

Railway Facilities at Nottingham. Reviews the stations that have been in service in this English city, describing particularly the Victoria and the Midland stations recently built. Plans. 2800 w. Engr, Lond—April 30, 1909. No. 4631 A.

The Development and Present Transformation of Railway Facilities in Cologne (Die Entwicklung und gegenwärtige Um-

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gestaltung der Bahnanlagen in Cöln). Herr Wienecke. Reviews improvements to stations and yards. Ills. 8000 w. Glasers Ann—April 1, 1909. No. 5055 D.

Terminals.

New York Passenger Terminal, Central R. R. of New Jersey. Interesting features of the new terminal at the foot of Liberty St. are illustrated and described. 2500 w. Eng Rec—May 22, 1909. No. 4924.

Tie Rods.

A Suggestion for Tie Rods. H. Herden. Describes the proposed use of rods to prevent the spreading of rails, explaining the advantages claimed. Ills. 1500 w. R R Age Gaz—May 21, 1909. No. 4901.

Track Maintenance.

See Curves, under PERMANENT WAY AND BUILDINGS.

TRAFFIC.

Car Efficiency.

A. R. A. Report on Car Efficiency. Extracts from the report presented May 19, at the New York meeting. 2000 w. R R Age Gaz—May 28, 1909. No. 5049.

Car Interchange.

Report of Committee of the Railway Club of Pittsburgh on Revision of M. C. B. Rules of Interchange. Gives the changes recommended, with discussion. 10000 w. Pro Ry Club of Pittsburgh—March 26, 1909. No. 4527 C.

Freight.

Traffic Studies. Ray Morris. This first article of a series deals with the traffic on the lines of the Oregon Railroad & Navigation Company. 2800 w. R R Age Gaz—May 7, 1909. Serial. 1st part. No. 4561.

Freight Rates.

Railway Rate Making in Practice. William Z. Ripley. Discusses problems to be solved in the development of a rate sheet. Diagrams. 3300 w. R R Age Gaz—May 7, 1909. Serial. 1st part. No. 4560.

Transcontinental Freight Rates. Editorial discussion of the charges against the present system, and the possible remedies. 3500 w. R R Age Gaz—May 14, 1909. No. 4656.

Passenger Rates.

The Passenger Rate of the American Railway. William S. Bronson. This first article of a series gives an explanation of the rates of fare generally in use. 1700 w. R R Age Gaz—May 28, 1909. Serial. 1st part. No. 5048.

MISCELLANY.

Alaska.

Railroads of the Copper River District, Alaska. H. S. Taylor. Map and description of the various projects, the region, and the development work. 2500 w. Min Wld—May 15, 1909. No. 4698.

Australia.

Government Railways in Australia. G. H. Knibbs. Discusses the desirability of improved statistics. 1300 w. Aust Min Stand—March 24, 1909. Serial. 1st part. No. 4513 B.

England.

English Railways. William Wickham Turlay. Begins a study of features of English railways, considering in the present article the protection from accidents. 1100 w. R R Age Gaz—May 7, 1909. Serial. 1st part. No. 4563.

France.

The Construction of Railways in Department of the Cher (Notice sur la Construction des Chemins de Fer départementaux du Cher). M. Mayer. Reviews the financial, traffic and engineering problems connected with building 165 kilometres of lines of local interest in this part of France. Ills. 16000 w. Ann d Ponts et Chaussées—1909-I. No. 4811 E + F.

India.

Light Railways in India. Percy F. Martin. The present article shows the need of short branch railways, explains the conditions, and matters relating to the problems of their construction. 2500 w. Engr, Lond—April 23, 1909. Serial. 1st part. No. 4466 A.

Italy.

The Development of Railways in Italy in Relation to the National Economic Development (Lo Sviluppo delle Strade ferrate in Italia esaminato in Relazione al Progresso economico nazionale). A. Gullini. Ills. Serial. 1st part. 8000 w. Ing Ferro—April 16, 1909. No. 4850 D.

Long Island.

The Long Island. Editorial review of conditions of a road whose business is largely suburban service, and of the means being tried to put the road on a profitable basis. 1200 w. R R Age Gaz—May 14, 1909. No. 4657.

Management.

Organization. H. Wade Hibbard. Discusses organization conducive to harmonious action in railway management. 4500 w. Pro St. Louis Ry Club—April 9, 1909. No. 4543.

The Operating Organization of the Union Pacific and Southern Pacific Systems. Julius Kruttschmitt. From a paper read before the N. Y. R. R. Club. Gives a chart showing in detail the organization, giving also full particulars and statistics. Inset. 7000 w. R R Age Gaz—May 28, 1909. No. 5046.

Methods of the Santa Fé: Efficiency in the Manufacture of Transportation. Charles Buxton Going. This fourth article of a series deals with the administration, supervision and extension of the bonus system. 5000 w. Engineering Magazine—June, 1909. No. 4984 B.

We supply copies of these articles. See page 723.

STREET AND ELECTRIC RAILWAYS.

Car Barns.

Large New Car House of Chicago City Railway. Illustrated detailed description of the constructional features. 3500 w. Elec Ry Jour—May 8, 1909. No. 4536.

Car Maintenance.

Piece-Work Rates Used by the Third Avenue Railroad Company, New York. Explains the use of this system for car-maintenance work, giving rates for different contracts. 2000 w. Elec Ry Jour—May 15, 1909. No. 4651.

Rolling Stock Standardization in Brooklyn—Records and Forms. Explains the use of the record system in car maintenance, the bases of inspection and repair, etc. 3500 w. Elec Ry Jour—May 29, 1909. Serial. 1st part. No. 5000.

Car Ventilation.

Results of a Study of Car Ventilation in Chicago. Gives ventilation experiments made by J. F. Biehn and J. B. Gooken, with brief descriptions of systems tested and results. 3500 w. Elec Ry Jour—May 8, 1909. No. 4538.

Crossing Gates.

An Automatic Grade-Crossing Gate. J. B. van Brussel. Brief illustrated description of a crossing gate for electric railways, installed near Montreux, on Lake Geneva. 600 w. Eng News—May 20, 1909. No. 4782.

Direct Current.

Electric Traction by Constant Intensity Continuous Current (Sur la Traction par le Courant continu à Intensité constante). J. Bourdel. An illustrated discussion of the system. 7800 w. Bul Soc Int des Elecns—April, 1909. No. 4817 F.

Locomotives.

Experimental Electric Locomotive. Illustrated description of a design for the purpose of trying a scheme of transmitting power to the drive wheels through side rods; also editorial. 2200 w. Ry & Engng Rev—May 15, 1909. No. 4740.

A New Side-Rod Electric Locomotive. Illustrated description of a novel type recently built and tested. 1500 w. Elec Ry Jour—May 8, 1909. No. 4537.

The F 4/4 Electric Locomotives on the Simplon Railway (Die elektrischen F 4/4-Lokomotiven am Simplon). E. Thomann and K. Schnetzler. Illustrated detailed description. Serial. 1st part. 4400 w. Zeitschr d Ver Deutscher Ing—April 17, 1909. No. 5074 D.

London.

The Electrical System of the L. C. C. Tramways. Abstract of J. H. Rider's paper before the Inst. of Elec. Engrs. Illustrated description of the electric power supply. 3500 w. Elec Rev, Lond—April 30, 1909. Serial. 1st part. No. 4601 A.

Motor Suspension.

Motor Suspension on Electric Cars (Die güngstigste Motoraufhängung bei elektrischen Fahrzeugen). G. Brecht. A discussion of the factors influencing the location of the motor. Ills. 2500 w. Elek Kraft u Bahnen—April 3, 1909. No. 5061 D.

Paris.

The Metropolitan of Paris (Le Chemin de Fer Métropolitan de Paris). R. Godfernaux. A review of recent developments. Ills. 14000 w. Rev Gen d Chemins de Fer —April, 1909. No. 4823 G.

Rawtenstall.

Rawtenstall Corporation Tramways. Illustrated description of English tramways recently opened. Map. 3000 w. Tram & Ry Wld—May 6, 1909. No. 4954 B.

Single-Phase.

Conversion of New Canaan Branch from 500-Volt D. C. to 11,000-Volt A. C. Operation. Brief illustrated description of the line and rolling stock on the branch from Stamford to New Canaan, Conn. 800 w. Elec Ry Jour—May 15, 1909. No. 4650.

The Application of Single-Phase Current to the Borinage Railway (Application du Courant monophasé au Chemin de Fer vicinal du Borinage). P. Rodigas. Illustrated description of the lines, equipment, etc. Soc Belge d'Elecns—April, 1909. No. 4815 E.

Subways.

Extensive Engineering Undertaking. Information from the report of the Royal Commission appointed by the Government of New South Wales to suggest the best practical method of establishing direct communication between the northern and southern sides of Sydney Harbor. Recommends an electric tube railway. Map. 2500 w. Aust Min Stand—April 7, 1909. No. 4619 B.

Electrical Equipment of the Washington Street Subway, Boston. Illustrated description of the arrangements for the supply of power and lighting. 3000 w. Elec Ry Jour—May 22, 1909. No. 4795.

Test Cars.

An Electric Street Railway Test Car (Ein elektrischer Strassenbahnmesswagen). R. Shoengarth. Illustrated description of the car used in Cologne and its equipment. 1600 w. Elek Kraft u Bahnen —April 3, 1909. No. 5062 D.

United States.

Peculiarities of Electric-Railway Practice in the United States (Die elektrischen Bahnen der Vereinigten Staaten und ihre Eigenheiten). Eugen Eichel. Discusses points of difference from Continental practice. Ills. 2000 w. Elek Kraft u Bahnen—Feb. 24, 1909. No. 4803 D.

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EXPLANATORY NOTE—THE ENGINEERING INDEX.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m.*, a bi-monthly, *t-m.*, a tri-monthly, *qr.*, a quarterly, *s-q.*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Jl. of Science. *m.* New Haven, U. S. A.
American Machinist. *w.* New York.
Anales de la Soc. Cien. Argentina. *m.* Buenos Aires.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. Ing. d Arch Ital. *s-m.* Rome.
Applied Science. *m.* Toronto, Ont.
Architect. *w.* London.
Architectural Record. *m.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Melbourne.
Autocar. *w.* Coventry, England.
Automobile. *w.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Boiler Maker. *m.* New York.
Brass World. *m.* Bridgeport, Conn.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bull. Bur. of Standards. *qr.* Washington.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin du Lab. d'Essais. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. of Can. Min. Inst. *qr.* Montreal.
Bull. Soc. Int. d'Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bull. Int. Railway Congress. *m.* Brussels.
Bull. Scien. de l'Assn. des Elèves des Eccles Spéc. *m.* Liége.
Bull. Tech. de la Suisse Romande. *s-m.* Lausanne.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *w.* Toronto and Montreal.
Canadian Mining Journal. *b-w.* Toronto.
Cassier's Magazine. *m.* New York and London.
Cement. *m.* New York.
Cement Age. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Clay Record. *s-m.* Chicago.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.

Comptes Rendus de l' Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Cornell Civil Engineer. *m.* Ithaca.
Der Motorwagen. *s-m.* Berlin.
Deutsche Bauzeitung. *b-w.* Berlin.
Die Turbine. *s-m.* Berlin.
Domestic Engineering. *w.* Chicago.
Economic Geology. *m.* New Haven, Conn.
Electrical Age. *m.* New York.
Electrical Engineer. *w.* London.
Electrical Engineering. *w.* London.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electric Journal. *m.* Pittsburg, Pa.
Electric Railway Journal. *w.* New York.
Electrical World. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Elektrische Kraftbetriebe u Bahnen. *w.* Munich.
Electrochemical and Met. Industry. *m.* N. Y.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnik u Maschinenbau. *w.* Vienna.
Elektrotechnische Rundschau. *w.* Potsdam.
Elettricità. *w.* Milan.
Engineer. *w.* London.
Engineering. *w.* London.
Engineering-Contracting. *w.* New York.
Engineering Magazine. *m.* New York and London.
Engineering and Mining Journal. *w.* New York.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penna. *m.* Pittsburg, U. S. A.
Foundry. *m.* Cleveland, U. S. A.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giesserei-Zeitung. *s-m.* Berlin.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Heating and Ventilating Mag. *m.* New York.
Ice and Cold Storage. *m.* London.
Ice and Refrigeration. *m.* New York.
Il Cemento. *s-m.* Milan.
Industrial Engineering. *m.* Pittsburg.
Industrial World. *w.* Pittsburg.
Ingegneria Ferroviaria. *s-m.* Rome.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Int. Marine Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. of Accountancy. *m.* N. Y.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal Franklin Institute. *m.* Philadelphia.
Jour. Ind. & Engng. Chem. *m.* Easton, Pa.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Jour. Roy. United Service Inst. *m.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Jour. Transvaal Inst. of Mech. Engrs., Johannesburg, S. A.
Jour. of U. S. Artillery. *b-m.* Fort Monroe, U. S. A.
Jour. W. of Scot. Iron & Steel Inst. *m.* Glasgow.
Journal Western Soc. of Eng. *b-m.* Chicago.
Jour. of Worcester Poly. Inst., Worcester, U. S. A.
Locomotive. *m.* Hartford, U. S. A.
Machinery. *m.* New York.
Manufacturer's Record. *w.* Baltimore.
Marine Review. *m.* Cleveland, U. S. A.
Mechanical Engineer. *w.* London.
Mechanical World. *w.* Manchester.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Métallurgie. *w.* Paris.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco.
Mining Journal. *w.* London.
Mining World. *w.* Chicago.
Mittheilungen des Vereines für die Förderung des Local- und Strassenbahnwesens. *m.* Vienna.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *w.* New York.
Nautical Gazette. *w.* New York.
New Zealand Mine Record. *m.* Wellington.
Oest. Wochensch. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg & Hüttenwesen. *w.* Vienna.
Plumber and Decorator. *m.* London.
Power and The Engineer. *w.* New York.
Practical Engineer. *w.* London.
Pro. Am. Ins. Electrical Eng. *m.* New York.
Pro. Am. Ins. of Mining Eng. *m.* New York.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Am. Soc. Mech. Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. Engrs. Soc. of Western Pennsylvania. *m.* Pittsburg.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Pro. U. S. Naval Inst. *qr.* Annapolis, Md.
Public Works. *qr.* London.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Age Gazette. *w.* New York.
Railway & Engineering Review. *w.* Chicago.
Railway and Loc. Engng. *m.* New York.
Railway Master Mechanic. *m.* Chicago.
Revista Tech. Ind. *m.* Barcelona.
Revue d'Electrochimie et d'Electrométallurgie. *m.* Paris.
Revue de Mécanique. *m.* Paris.
Revue de Métallurgie. *m.* Paris.
Revue Gén. des Chemins de Fer. *m.* Paris.
Revue Gén. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
School of Mines Quarterly. *q.* New York.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Eng. *m.* Ithaca, N. Y.
Signal Engineer. *m.* Chicago.
Soc. Belge des Elect'ns. *m.* Brussels.
Stahl und Eisen. *w.* Düsseldorf.
Stevens Institute Indicator. *qr.* Hoboken, U. S. A.
Surveyor. *w.* London.
Technik und Wirtschaft. *m.* Berlin.
Technique Moderne. *m.* Paris.
Tramway & Railway World. *m.* London.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Wood Craft. *m.* Cleveland, U. S. A.
Yacht. *w.* Paris.
Zeitschr. f. d. Gesamte Turbinenwesen. *w.* Munich.
Zeitschr. d. Mitteleurop. Motorwagen. Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift. für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Werkzeugmaschinen. *b-w.* Berlin.